FEBRUARY • 1947
VOLUME XVIII NUMBER 5

the Petroleum Engineer

...ds for Operating Men

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March 12—Institute of Petroleum, Manson House, 26, Portland Place, London, W. 1, England.
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March 22-28—Western Metal Congress and Exposition, San Francisco-Oakland Golden Gate area, California.
March 24-27—Western Petroleum Refiners, annual meeting, San Antonio, Texas.
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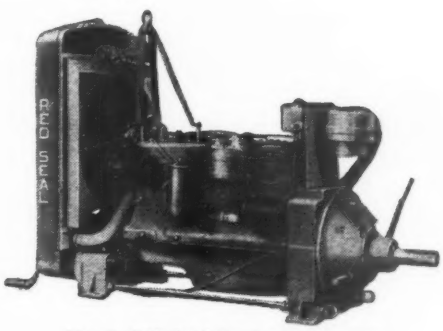

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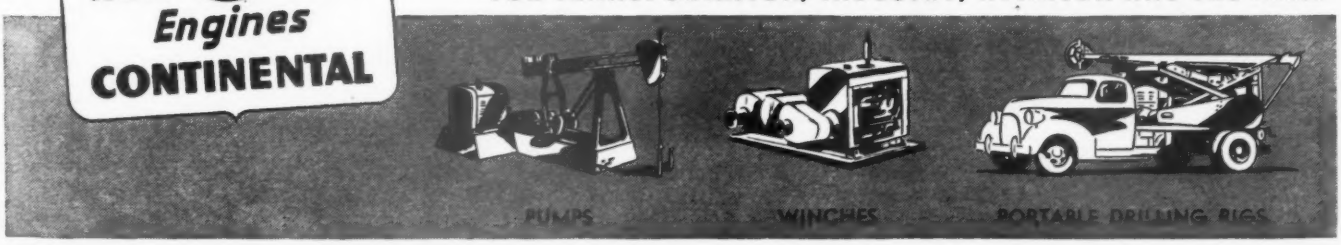


IS PESSIMISM WARRANTED?

When year-end estimates of domestic oil reserves begin to appear, the adequacy of oil reserves to care for the nation's future requirements immediately becomes a subject of scrutiny and discussion. Being a subject on which there is a wide variance of opinion, it is perhaps to be expected that pessimism and apprehension should be felt regarding the sufficiency of U. S. oil reserves. There is, perhaps, undue pessimism on this point that is not warranted.

Mounting discovery costs, coupled with lagging rate in the finding of new oil reserves in the United States, have been in evidence now for several years. For the year 1946, both the trend of discovery cost and that of rate of discovery are unchanged and show no sign of a reversal. If anything, both trends are more pronounced and so give rise to misgivings regarding the adequacy of U. S. oil reserves to meet the nation's future needs.

According to H. J. Struth, whose data on operations for 1946 are covered in an article in this issue, discoveries declined 41 per cent in the last four years compared with 1935-38 and this despite an increase in exploration effort of 50 per cent and in exploration expenditures of 223 per cent. For the last six years an average of eight dry holes were drilled for each million barrels of new oil reserves discovered; during 1946, eighteen dry holes were drilled for each million barrels of new reserves discovered.

Although these are factual data and beyond refutation, they nevertheless may be subject to misinterpretation that in turn may lead to fallacious reasoning that at once can be not only misleading, but harmful. Whether there is any justification for the pessimism that now prevails regarding domestic oil reserves, only time will tell.

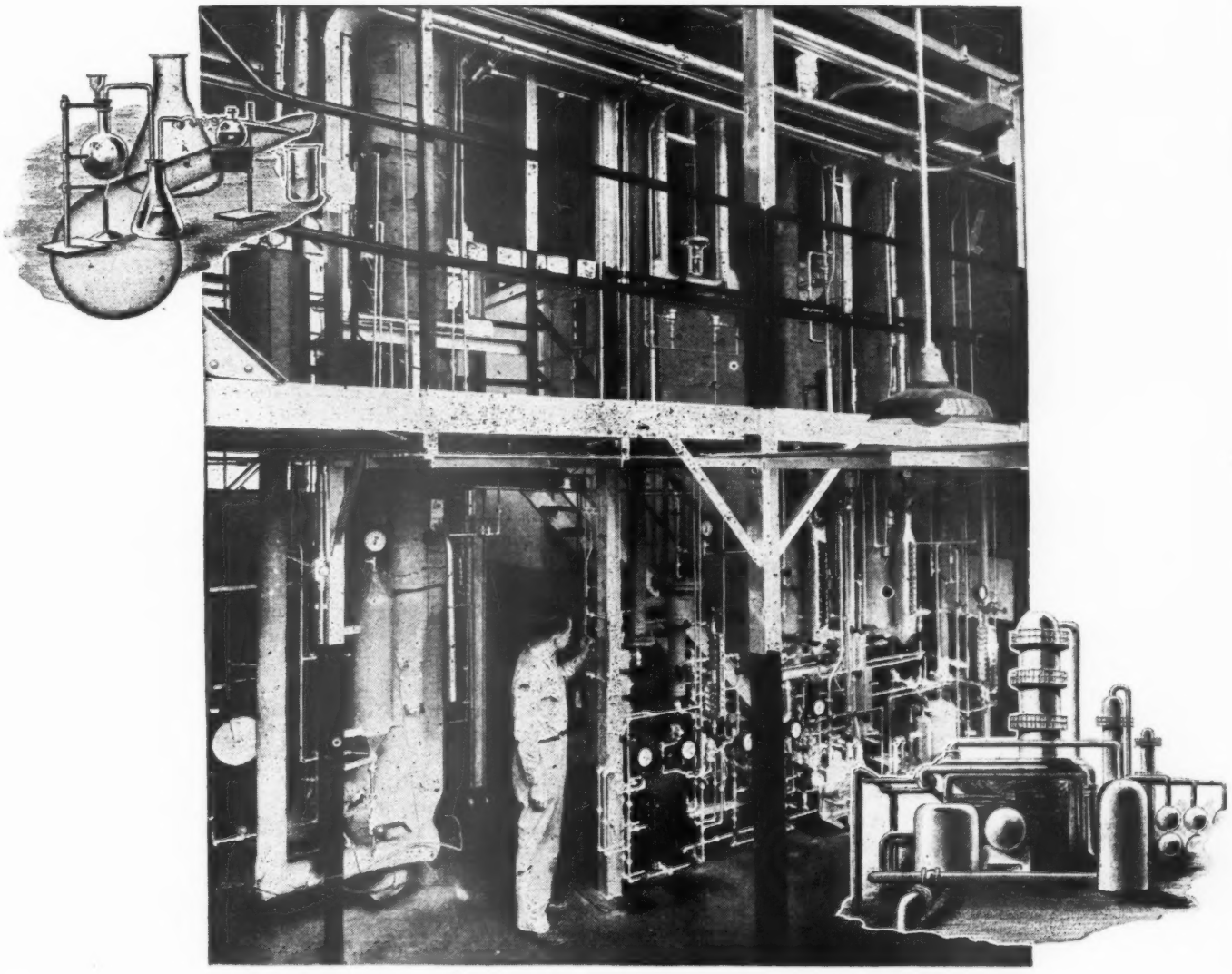
During a period of 23 years, excluding the years 1926 to 1930—the period during which Kettleman Hills, Oklahoma City, and East Texas fields were discovered—there were, on the average, 166 barrels of oil reserves for each 100 barrels of oil produced. During the last eight years, however, there were, on the average, 75 barrels of oil reserves for each 100 barrels of oil produced. This declining ratio of reserves to production is a figure that serves as a warning to the industry and signals the need for greater exploratory effort. Consider, however, the trend of domestic oil reserves from yet another angle: Notwithstanding the fact that the annual crude production in the U. S. during 1946 was the highest in history, yet the oil reserves on January 1, 1947, were greater by about one billion barrels than on January 1, 1946.

The pessimism that exists regarding the adequacy of domestic oil reserves to meet future needs may stem from little or no distinction being made between proved oil reserves and potential oil reserves. Proved oil reserves, although they are important in supplying current needs, are not an index of potential reserves, greater dependence on which, after all, must be placed to supply our more remote future requirements.

Throughout the history of the oil industry there have been recurrent periods of feast and famine in the production of crude oil. At such periods in the early days of the industry, yes, even until quite recently, no thought was given to the resultant harm to the reservoir by overproduction; the price of crude was the sole factor that entered to restore the balance between supply and demand. Price served to put the brakes on overproduction as well as to encourage the exploratory incentive that resulted in increasing the proved oil reserves. Today, crude price is still an all-important factor in increasing domestic oil reserves, and in addition, is greatly facilitated by our tremendous back-log of valuable technical knowledge and skills acquired in the science of field exploration and development.

It is to be noted that the period 1926 to 1930 was one of high discovery rate. Who can say, in the light of the vast potential areas that still remain to be explored, that the trend of oil discovery rate will not turn abruptly upward. This is not idle hope, if the past history of oil in the United States and the potential areas yet remaining to be explored are to be considered.

Even after all the data and trends on domestic oil reserves are thoroughly analyzed, they give no hint of when another East Texas will be discovered. Such a discovery is well within the realm of probability when one takes into account potential oil areas still remaining to be explored for oil. Besides acquired knowledge, skills, and techniques, the law of probability has to be reckoned with and holds out hope of discovery, in the future, of fields as large as those discovered in the past.—K. C. S.



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SCANNING WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—There is danger that the industry may discount the rekindled interest in the extent of our petroleum resources, remembering the Ickes-type of "oil shortage" alarms in the early 1930's when we had more than plenty of oil. But there is this difference now, the military is taking a hand.

Much is being made of the fact that we entered the last war with a reserve productive capacity of about a million barrels daily whereas today the United States is producing at about the maximum efficient rate. For those inclined to "view with alarm," this is something they can put their teeth into.

Also, there is the upward trend of imports with the 1946 rate of 378,000 B/D topping even the 1922 record. The United States continued to be a net exporter of oil but only by the narrow margin of about 37,000 B/D for the whole year. In December, imports averaged 442,000 B/D, which was well above the export rate of 1946.

Interior Secretary Krug's annual report stresses that the rate of finding new oil is declining, adding, "we are living on past discoveries and the hope that there will be more."

Chairman O'Mahoney of the Senate Petroleum Committee harps on the same note. After a two-year investigation, his committee concludes—and this was played up in the newspapers and on the radio—that this country could not fight another major war if we had to reply on our own petroleum resources alone.

Military authorities were impressed by the O'Mahoney Committee's conclusions on military oil supply, since it tended to confirm their own opinion. But the military isn't ready to agree with O'Mahoney that synthetic fuel is the answer.

How long, they ask, would it take to develop a synthetic fuel industry capable of filling any gap, up to two or three million barrels daily, between wartime demand and supply from domestic petroleum resources?

Primarily, however, the military wants to know exactly what is the productive capacity of our domestic petroleum resources to meet the all-out demands of another war.

So, Interior's Oil and Gas Division is undertaking to find the answer. OGD is studying what types of oil data are now being gathered by the government and industry. This will be measured against the information desired by the Army and Navy, as well as other government agencies. Results will be submitted to the National Petroleum Council's temporary statistical committee.

OGD hopes that the NPC, at its April meeting, can be induced to drop its opposition to a Council committee being set up to help assemble data on the availability of oil. (One factor in NPC's hesitancy was that this might be construed as putting the Council's endorsement, in advance, on any conclusions on oil supply drawn from such data.)

Interior is just as determined as the military to get oil availability data, and wants the job of compiling it. Krug's annual report spoke of the need for an oil inventory, saying, "it is necessary for us to have reliable, disinterested yearly estimates of our efficient productive capacity."

There have been vague rumors that the White House was considering a suggestion for a "quickie" inventory of oil resources, with perhaps a proclamation calling upon the industry to supply the basic data for compilation by Interior.

Another topic getting attention from both O'Mahoney and Krug is the utilization of natural gas.

The Wyoming senator, who is sponsoring legislation to double Interior's $30,000,000 synthetic fuel program, opposes pipelining of gas to the East, believing that it could be better reserved for making liquid fuel than competing with coal.

Krug has the industry wondering what part he would have Interior—or any other federal agency—play in gas conservation. His annual report spoke of the industry and the states *and* the federal government participating in a program for greater utilization of flared gas.

The question of whether Krug favors "end use" control was also raised in some minds by the passage in his report saying there isn't enough oil "to permit wasteful practices in its production, handling and use."

A similar note was struck in a recent speech by Undersecretary of Interior Chapman in commenting on the use of oil and gas—both of which he described as being in "diminishing" supply—for producing steam in competition with coal in the East. This "low-grade use" may bring higher gasoline prices later and drive us "into old-fashioned European imperialism to get oil abroad," Chapman declared.

Chapman may or may not have had the Middle East in mind. But if there are any officials who have apprehensions that expansion of American oil interests in this area may have "imperialistic" implications, none has voiced such sentiments. On the contrary, there has been quiet approval of the general idea. Only criticism has been that too few companies are participating. And the State Department has sought to answer that by trying to interest other companies—including independents—in nonconcessioned areas in the Middle East.

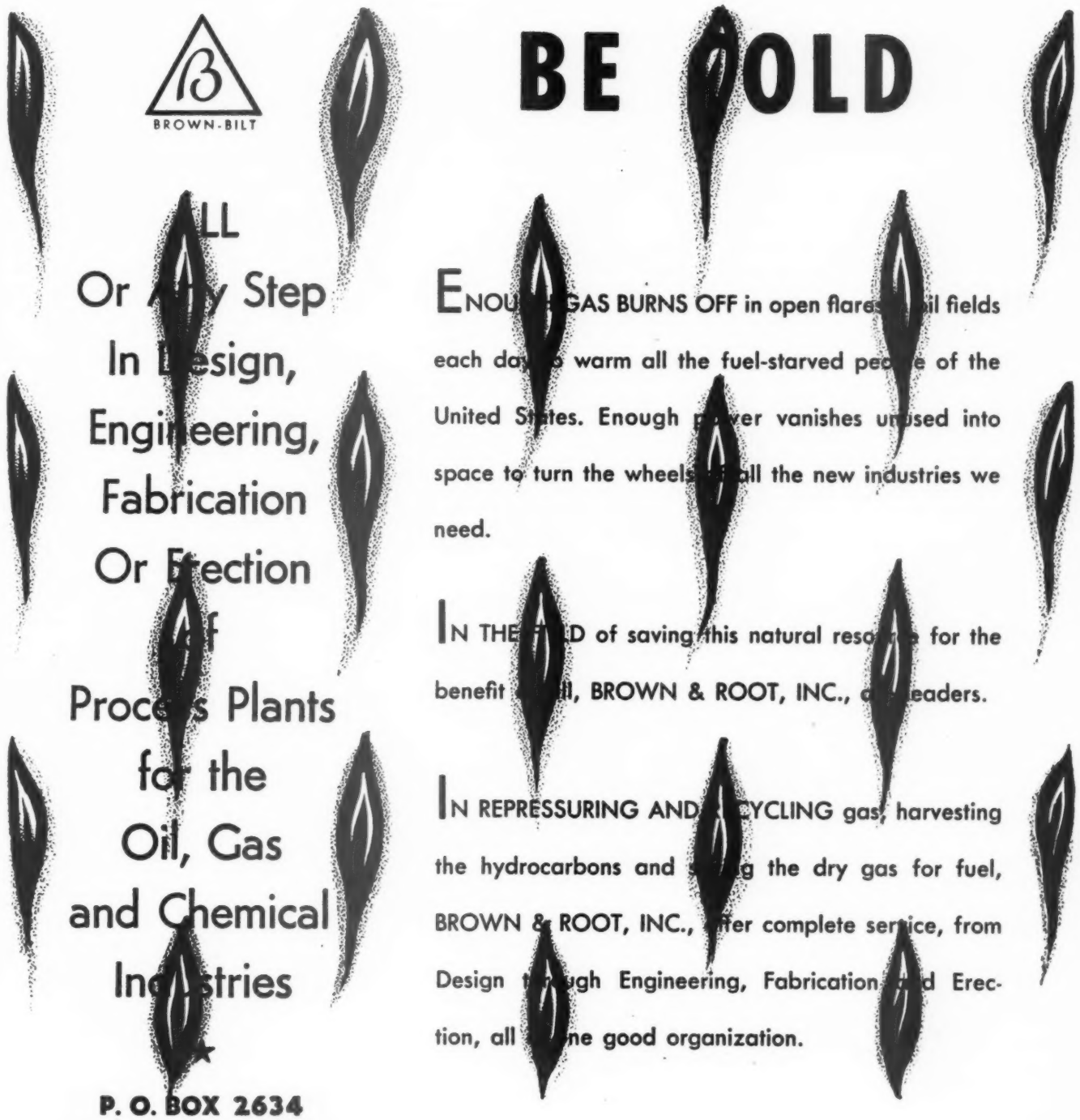
The military has given its blessing, from the standpoint that any expansion of American oil holdings abroad tends to stretch our domestic reserves. Although they haven't shouted it from the housetops—yet, the military is much concerned over oil supply in their national defense planning. This springs from their responsibility to be prepared for another war if it comes next month, next year or 5, 10, or 15 years from now.

Lately, however, some military men have tempered their enthusiasm for Middle East oil, wondering what would be the effect on domestic producers. They want a strong, healthy domestic industry, plus nearby, well-developed reserves in the Caribbean area, which would be accessible if other foreign areas were cut off.

Such thinking has given them a better appreciation of the viewpoint of the independent producer who, fearing that foreign oil may flood his market here, depress crude prices below cost and leave him with no capital or incentive to find and develop new reserves in this country, is urging that the oil tariff be increased and import quotas imposed.

What price Middle East oil development, if a flood of foreign oil should hamstring the domestic industry and retard development in Venezuela, was the way one military leader worded this sobering thought.

NO ONE NEED EVER BE COLD



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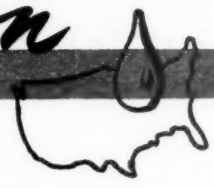


By H. J. STRUTH,* *Petroleum Economist*

STOCKS REDUCED. Preliminary figures for January indicate substantial reduction in crude and refined inventories. Overall stocks were reduced 15,310,000 bbl; stocks of refined products were cut 11,500,000; crude stock cut 3,810,000 bbl. The result changed industry's stock position to a more favorable level compared with December.

DEMAND EXCEEDS SUPPLY. Crude demand in January averaged 4,994,000 bbl daily, while supply, including imports, averaged 4,871,000 bbl daily. This marks a decided improvement over situation prevailing throughout most of 1946, particularly compared with a year ago. Crude demand was 6 per cent above year ago.

INCREASED DRILLING. Well completions in January aggregated 2513 against 2357 year ago, an increase of 7 per cent. Wildcat operations increased 13 per cent over year ago. Projections for 1947 indicate likelihood that over 31,000 wells will be completed, and of this at least 5110 wildcat wells will be drilled. Continued shortages of steel are expected to retard drilling operations for at least first six months of this year; otherwise, it may have been possible to drill over 32,000 wells this year.

HIGH DEMAND. January motor fuel demand, including exports, averaged 1,994,000 bbl daily, compared with 1,828,000 bbl year ago, an increase of 9 per cent. Fuel oil demand in January averaged 2,645,000 bbl daily compared with 2,507,000 bbl daily year ago, an increase of 5 per cent. Demand for other products was commensurately higher.

YIELD CHANGES. Gasoline yield from crude oil in January averaged about 40.3 per cent compared with 38 8 per cent year ago, a net increase of 1.5 per cent. Fuel oil production was correspondingly reduced in January and appears to be about 2 per cent below production rate a year ago. Fuel oil stocks were 47 per cent above year ago, which accounts for the switch to more gasoline.

*Editor, *The Petroleum Data Book.*

Comparative Statistics, January, 1947

*All figures are computed on a Bureau of Mines' Basis**

	Jan. 1947(p)	Dec. 1946(p)	Jan. 1946	This year to date	Last year to date	Per cent change
Wells drilling	3,900	¶4,000	4,260	3,900	4,260	− 8
Total wells drilled	2,513	2,533	2,357	2,513	2,357	+ 7
Development wells	2,122	2,122	2,012	2,122	2,012	+ 5
Oil	1,299	1,271	1,264	1,299	1,264	+ 3
Gas	259	269	201	259	201	+29
Dry	564	582	547	564	547	+ 3
Per cent dry	26.6	27.4	27.2	26.6	27.2	− 0.6
Wildcat wells	391	411	345	391	345	+13
Oil	42	44	35	42	35	+20
Gas	10	13	9	10	9	+11
Dry	339	354	301	339	301	+13
Per cent dry	86.7	86.1	87.2	86.7	87 2	− 0.5
Crude supply*	150,990	152,822	150,285	150,990	150,285	0
Daily average	4,871	4,930	4,848	4,871	4,848	
Crude demand‡	154,800	¶154,000	145,548	154,800	145,548	+ 6
Daily average	4,994	4,968	4,695	4,994	4,695	
Crude stocks	226,800	¶230,610	227,996	226,800	227,996	− 1
Days supply	45	46	49	45	49	
Natural gasoline production	10,160	10,240	9,882	10,160	9,882	+ 3
Daily average	328	330	319	328	319	
Motor fuel production	67,760	68,300	62,126	67,760	62,126	+ 9
Daily average	2,186	2,203	2,004	2,186	2,004	
Gasoline yield, per cent	40.3	40.7	38.8	40 3	38.8	+ 1.5
Motor fuel demand‡	61,800	62,160	56,659	61,800	56,659	+ 9
Daily average	1,994	2,005	1,828	1,994	1,828	
Motor fuel stocks^	98,260	92,300	99,149	98,260	99,149	− 1
Days supply	49	45	54	49	54	
Fuel oil production	60,930	¶61,500	62,330	60,930	62,330	− 2
Daily average	1,965	1,984	2,011	1,965	2,011	
Fuel oil demand‡	82,000	77,800	77,732	82,000	77,732	+ 5
Daily average	2,645	2,510	2,507	2,645	2,507	
Fuel oil stocks	93,500	109,900	63,563	93,500	63,563	+47
Days supply	35	43	25	35	25	
Refinery still runs	148,160	¶148,500	140,130	148,160	140,130	+ 6
Daily average	4,779	4,790	4,520	4,779	4,520	
All refined stocks	275,500	287,000	233,247	275,500	233,247	+18
Days supply	48	51	43	48	43	

Economic Position of U. S. Petroleum Industry

One Month Ending January 31, 1947

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	2,635	2,513	95
Production (daily crude output)	4,545	4,645	102
Refining (daily still runs)	4,740	4,779	101
Stocks (crude and refined)	514,300	502,300	98
Price of crude (per bbl)	$1.88**	$1.65	88

Crude Prices By States for January, 1947

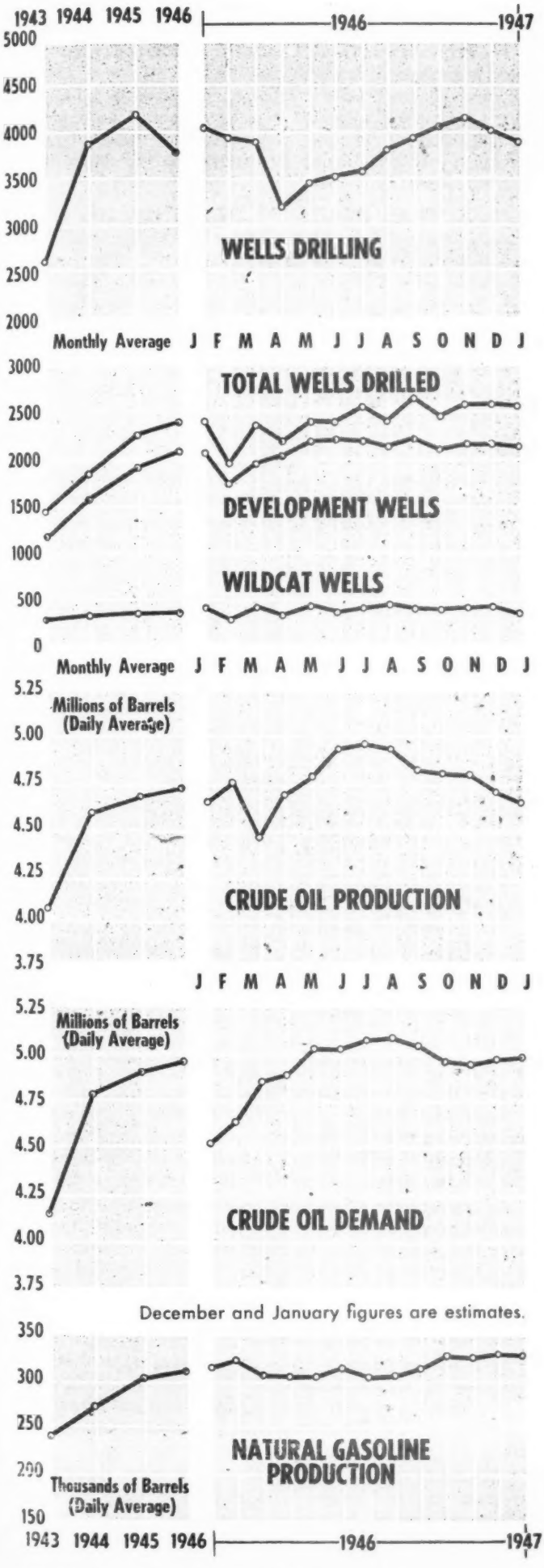
U. S. average	$1.65	Louisiana	$1.67	**Basic crude prices**	
Texas	1.66	Arkansas	1.48	Oklahoma-Kansas (36 gr.)	$1.62
California	1.41	New Mexico	1.45	Texas Gulf Coast (36 gr.)	1.85
Oklahoma	1.68	Mississippi	1.47	East Texas	1.70
Kansas	1.67	Illinois	1.84	West Texas (36 gr.)	1.49
		Other states	2.28	Calif. Signal Hill (26 gr.)	1.46
				Pennsylvaynia, Bradford	3.20

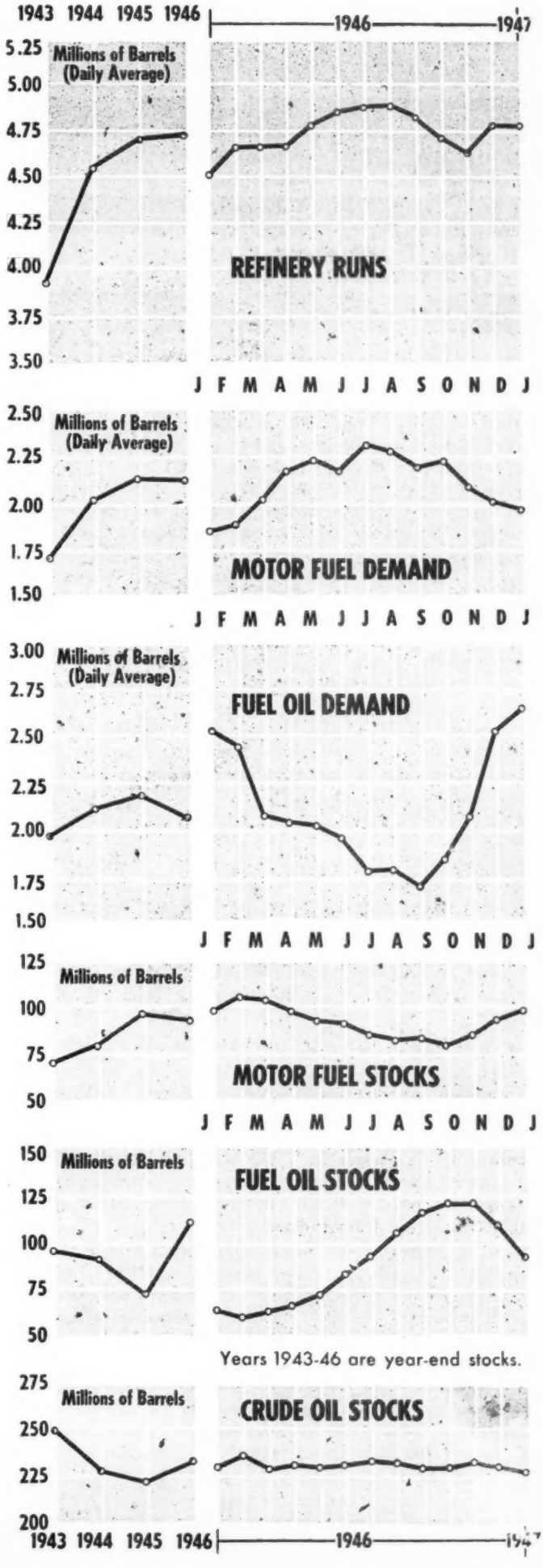
Drilling and Production Statistics by States

	Jan. 1947(p)	Dec. 1946(p)	Jan. 1946	This year to date	Last year to date	Per cent change
Total wells drilled	2,513	2,533	2,357	2,513	2,357	+ 7
Texas	625	648	675	625	675	− 7
California	170	111	156	170	156	+ 9
Oklahoma	351	319	212	351	212	+ 66
Kansas	211	233	191	211	191	+ 10
Louisiana	102	116	102	102	102	0
Arkansas	23	19	11	23	11	+109
New Mexico	42	43	44	42	44	− 5
Mississippi	35	42	23	35	23	+ 52
Illinois	166	216	178	166	178	− 7
Other states	788	784	765	788	765	+ 3
Wildcats drilled	391	411	345	391	345	+ 13
Texas	116	139	108	116	108	+ 7
California	25	33	24	25	24	+ 4
Oklahoma	72	88	54	72	54	+ 33
Kansas	29	24	31	29	31	− 6
Louisiana	20	18	10	20	10	+100
Arkansas	5	9	1	5	1	+400
New Mexico	5	2	10	5	10	− 50
Mississippi	11	16	5	11	5	+120
Illinois	40	34	41	40	41	− 2
Other states	68	48	61	68	61	+ 11
Daily crude production	4,645	4,703	4,625	4,645	4,625	0
Texas	1,952	2,002	2,037	1,952	2,037	− 4
California	881	871	839	881	839	+ 5
Oklahoma	359	369	386	359	386	− 7
Kansas	255	276	254	255	254	0
Louisiana	423	418	374	423	374	+ 13
Arkansas	76	78	77	76	77	− 1
New Mexico	106	106	98	106	98	+ 8
Mississippi	83	83	55	86	55	+ 56
Illinois	197	202	206	197	206	− 4
Other states	310	298	299	310	299	+ 4

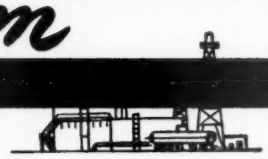
*Unless otherwise stated all figures represent thousands of barrels. ***Does not include input wells. (p) Preliminary. ^Includes domestic production and imports.
‡Total demand, including exports. ¶Revised. **Price 1926 (Index 100). ^Includes finished and natural gasoline.

PRELIMINARY ESTIMATES BASED UPON DATA FURNISHED BY AMERICAN PETROLEUM INSTITUTE, U. S. BUREAU OF MINES, STATE AGENCIES AND OTHER OFFICIAL SOURCES.


1943 1944 1945 1946 1946 1947
WELLS DRILLING
Monthly Average J F M A M J J A S O N D J
TOTAL WELLS DRILLED
DEVELOPMENT WELLS
WILDCAT WELLS
Monthly Average J F M A M J J A S O N D J
Millions of Barrels (Daily Average)
CRUDE OIL PRODUCTION
J F M A M J J A S O N D J
Millions of Barrels (Daily Average)
CRUDE OIL DEMAND
December and January figures are estimates.
Thousands of Barrels (Daily Average)
NATURAL GASOLINE PRODUCTION
1943 1944 1945 1946 1946 1947


1943 1944 1945 1946 1946 1947
Millions of Barrels (Daily Average)
REFINERY RUNS
J F M A M J J A S O N D J
Millions of Barrels (Daily Average)
MOTOR FUEL DEMAND
J F M A M J J A S O N D J
Millions of Barrels (Daily Average)
FUEL OIL DEMAND
J F M A M J J A S O N D J
Millions of Barrels
MOTOR FUEL STOCKS
J F M A M J J A S O N D J
Millions of Barrels
FUEL OIL STOCKS
Years 1943-46 are year-end stocks.
Millions of Barrels
CRUDE OIL STOCKS
1943 1944 1945 1946 1946 1947

highlights in oildom



● **API APPROVES OIL PACT.** The board of directors of the American Petroleum Institute has gone on record, in a resolution passed at its first 1947 quarterly meeting, as favoring ratification of the Anglo-American oil agreement in its present form. The action was based on a letter from William L. Clayton, undersecretary of state for economic affairs, in which he confirmed that the Institute's previous understanding and interpretation of the treaty was correct. Two years ago API interpreted the treaty as containing no domestic controls, with participation in it by American oil companies as purely voluntary. At its annual meeting in Chicago last November API asked the state department whether this interpretation was correct.

In his letter to William Boyd, president of the American Petroleum Institute, Undersecretary Clayton said that "the state department has no policy or program which contemplates the creation of a petroleum regulatory body and the pending Anglo-American agreement will provide neither basis for government regulation of the domestic or foreign petroleum industry nor for an extension of governmental powers with respect to the industry."

Clayton further stated that those parts of the original API resolution giving its understanding of the terms of the treaty were in complete accord with the understanding of the state department.

Outlining the provisions of the treaty, Clayton emphasized that it provides for a petroleum commission whose functions are of a consultive or advisory nature, without executive authority.

● **BACTERIA IN OIL RECOVERY.** The possibility of using certain types of bacteria to increase the recovery of oil from subterranean deposits is suggested by U. S. Patent No. 2,413,278 issued to Dr. Claude E. ZoBell, associate professor of microbiology at the University of California's Scripps Institution of Oceanography. The invention described by the patent relates to an improved process for increasing or facilitating the recovery of oil, gas, or other valuable fluids from fluid-bearing earth formations.

While testing various kinds of bacteria for their ability to modify crude oils, Dr. ZoBell observed in March, 1943, that certain cultures released droplets of oil from test tubes filled with calcareous material prepared to simulate underground oil-producing formations. Further experiments showed that the bacteria were able to release oil from samples of Athabaska tar sands and Santa Maria oily shales.

These observations were reported to the Advisory Committee on Occurrence and Recovery of Petroleum of the American Petroleum Institute, which was sponsoring the work as part of one of its fundamental research projects.

The advisory committee felt that the discovery was of sufficent importance to warrant protecting it for the benefit of the industry as a whole with appropriate letters patent. Dr. ZoBell assigned the patent to the American Petroleum Institute for the free use of the public everywhere.

The Pennsylvania Grade Crude Oil Association, also a nonprofit organization, has been cooperating in the investigations during the last two years in attempting to apply the discovery to the recovery of oil under field conditions. Although there are still technical difficulties to be overcome, the results so far are sufficiently encouraging to warrant a continuation of the field experiments.

● **U. S. FILES CLAIM TO TIDELANDS.** The United States government, in a brief filed with the Supreme Court, has claimed sole title to oil deposits beneath the marginal seas off the coast of California. The brief holds that the federal government and not the State of California holds title to the underwater lands extending three nautical miles from the low tide mark on the Pacific shores.

In its brief, the government said:

"If ownership of submerged land is an attribute of sovereignty . . . then the ownership of lands under the three-mile belt is more closely related to national sovereignty than to local sovereignty.

"The three-mile belt is a creature of international law and such governmental rights and powers as arise therefrom depend entirely upon the national government and may be vindicated as against other nations only by the national government."

The brief further said that when California was admitted to the union on an "equal footing" with other states in 1850, it became endowed with all the governmental powers that a state must have under our constitution; but, it added:

"It did not, however, succeed to the rights of the United States to property within its borders, except to the extent that such property rights were transferred to it by the United States."

It stressed that the United States, without dispute, has not, either by statute or otherwise, made any express conveyance of the disputed lands to California.

● **OIL INDUSTRY SPONSORS FELLOWSHIPS.** Fellowships now supported or under plan of establishment by the petroleum industry total 211 in 48 universities, according to a survey conducted by the American Petroleum Institute. The total yearly cost of these fellowships is $538,000.

The American Petroleum Institute points out that the survey was limited to those organizations known to be most interested in the subject and said it was considered to include at least 70 per cent of the fellowships supported by the industry.

The fellowships, which averaged $2550 annually, cover 42 subjects.

● **TO ASK SYNTHETIC RUBBER POLICY.** Representatives of the eight oil companies having operating and leasing arrangements with the government for ten butadiene plants are preparing to seek from Congress an official pronouncement of the national rubber policy, which would take cognizance of synthetic rubber in all general purpose rubber products.

An interagency industry advisory committee on rubber has recommended that these plants be transferred to private enterprise. Butadiene manufacture composes only a fraction of the process in making synthetic rubber, but for all general purpose rubber it was proposed the Congress stipulate that one-third or 250,000 tons, whichever should be the maximum, of the composition should be synthetic.

An extensive report is now being prepared by the butadiene operators urging that such action be taken by the Congress. J. B. Hadlock, executive officer of the office of rubber reserves, a division of the Reconstruction Finance Corporation, has stated that such a proposal has the support of RFC.

Representing an initial expenditure of $203,000,000, the ten plants operated by the major oil companies are still manufacturing butadiene and are operating at full capacity, according to Washington representatives.

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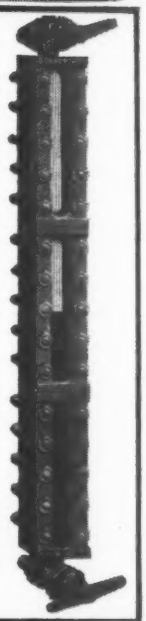
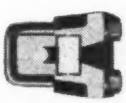
DROP FORGED STEEL LIQUID LEVEL GAGES



Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.



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WATER GAGE SET

For oil field, locomotive type and marine boilers. Water shows black—steam shows white; the water level is unmistakable. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler. Conforms with A.S.M.E., Federal and State requirements when used for pressures specified by their respective codes.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

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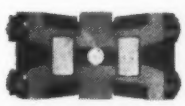
Used to observe color and density of liquids under high pressures and/or temperatures. Construction exceptionally sturdy. Made of alloy temperature resisting steel, and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Transparent" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.



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SUMP PUMPS

Used wherever seepage water accumulates, the Penberthy Automatic Electric Sump Pump and the Penberthy Automatic Drainer (water or steam operated) have demonstrated their superiority in this service. Simple and rugged design—copper and bronze construction throughout.

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The accepted method for assuring an uninterrupted supply of feed water to oil field boilers. Penberthy Automatic Injectors will supply feed water to boilers at minimum cost, are quickly and easily installed, reliable under most severe operating conditions, require little attention and no careful handling. Highest quality design and rugged construction.

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Use the power of steam, air or water under pressure to lift liquids. Being simple jet pumps they have no moving parts and require no lubrication. A variety of models to meet different conditions. Also used as water heaters.

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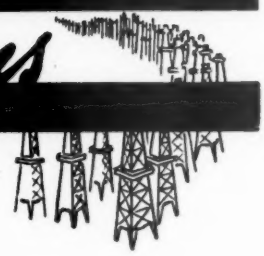
current oil field operations



• **OKLAHOMA.** Sohio Petroleum 1 Howard, SE SE NW 17-1n-2w, Garvin County, 100 bbl in 1 hr 39° 10,202 ft upper McLish. TD 10,234 ft.

Sinclair Prairie 1 Garrett, NW SW SE 13-5n-2w, Southwest Wayne field, McClain County, swabbed 94 bbl PB 7535. New zone. TD 7970 ft.

Westgate-Greenland 1 Wentz, SE SE NW 28-28n-1e, Kay County, 16 bbl 3524-40 ft. TD 3796 ft.

Standard of Kansas 1 Roberts, SW SW SE 15-10n-7e, Seminole County, 234 bbl 40° oil 3547-59 ft. TD 3572 ft.

Joe Blalock 1 Varner, NW NW 10-3s-11w, Cotton County, pump 47 bbl 1609-35 ft. TD 1635 ft.

Carter & Vierson 1 Hart, SE SE SE 23-3n-3w, Garvin County, pump 20 bbl Bromide 7206-28 ft. TD 7721 ft.

R. Olsen Oil 1 Ott, CWL SW SE 4-21-9w, Major County, gas and condensate 8015 ft Second Wilcox. TD 8124 ft.

G. C. Harwell 1 Greer, SW SW SW 24-2n-1w, Noble County, 71 bbl in 3¼ hr 4374-95 ft Bartlesville.

H. F. Gibson 1 Smith, NW NW SW 14-1s-5w, Carter County, oil 35° on drillstem 3439-45 ft. TD 3445 ft.

• **OHIO.** Ohio Fuel Gas 1 Wm. Gilgenbach, lot 26 Ridgeville twsp, Lorain County, 1,010,000 gas 2477-85 ft Clinton. TD 2490 ft.

• **INDIANA.** George & Wrather 1 Beloat, 8-2s-10w Gibson County, 160 bbl 1820-36 ft Cypress. TD 1841 ft.

• **KENTUCKY.** Fox & Fox 3 Grant, 14-P-28, Daviess County, pump 11 bbl 1488-500 ft Jackson. TD 1515 ft.

• **TEXAS.** H. W. Snowden Oil & Gas Co. 1 G. O. Hazelton, Sec 1995 T E & L Sur, Young County, pumped 84 bbl 42.8° grav. 3373-5 ft. TD.

Daniel Oil Co. 1 F. A. Cox, J. Scrutchfield Sur, Leon County, 72.5 bbl 33° grav 7100-404 ft. TD 7447 ft.

Clymore Co. Inc. 1 John L. Zarsky, J. M. Aldrete Grant, Refugio County, 1P 50 MM cu ft open 4926-37 ft. TD 7035 ft.

The Texas Co. 38 H. C. de Tijerina, Tijerina-Cunales field, 73 bbl new zone (17-B) 5990-6000 ft. TD 7472 ft.

V. F. Neuhaus 1 Loreto Canales, Sacatosa Grant, Starr County, pump 2 bbl 42° grav 1704-14 ft. Deepened 1602 to 1715 ft TD.

J. O. Clark 1 M. G. de Juarez, South Kelsey area, Starr County, 2 new zones, 124 bbl 42° grav 5817-6 ft. 144 bbl 5369-72 ft.

Standard of Kansas 1 August Pietsch, J. R. Phillips League, Fayette County, oil & gas on drillstem 6536-42 ft.

Claud B. Hamill 1 J. C. Stuart, Thos. Devers Sur, Cleveland area, Liberty County, 175 bbl 39° grav 5768-78 ft. TD 5782 ft.

Ohio Oil Co. 1-A Nada Unit, Indianola Sur, Sec 24, Nada field, Colorado County, gas & condensate, new zone 9910-16 ft. TD 10,332 ft.

Floyd L. Karsten 1-A W. P. Gann, E. T. RR Sur, Sec 25, Wharton County, gas & condensate 5678-82 ft. TD 7203 ft.

Johnston & Johnston 1 F. Surkamp, Tide Havenpool, Matagorda County, 38 bbl 43° 8533-35 ft. TD 10,055 ft.

J. W. Macom 6-A Ker Cade, W. M. Hudson Sur. High Island Dome, Galveston County, 371 bbl 34° oil 7141 ft. TD 7359 ft.

Rand Morgan 1-A Fee, Richard King area, Sec 5, Nueces County, 41 bbl 5605-9 ft. TD 5848 ft.

Stanolind Oil & Gas Co. 1 Kayser, Kayser pool, T & P Sur, Sec 34, Blk 43, Ector County, swabbed 7 bbl 1 hr 27° grav 8495 ft Cisco. TD 13,620 ft.

Magnolia Pet. Co. 2-B E. P. Cowden, SW SE Sec 4, PSL Sur, Dollar Hide field, Andrews County, 534 bbl 43.6° grav new zone 8345-65 ft. Silurian.

R. C. Lipscomb 1 K. N. & L. P. Hapgood "A", Marion Co. Sc. Ld. Sur 1, Blk 78, Clay County, pumped 224 bbl 1st day, 127 bbl 2nd day Strawn 4985-5002 ft TD.

R. T. Owens & Rhodes Drilling Co. 1 M. B. Hill, Coleman County, 200 bbl 3735-51 ft.

D. D. Feldman 16 Waggoner "A" Sec 31, H & T C Sur 1, Wichita County, 28 bbl 1790-809 ft. TD 2374 ft PB 1855 ft.

R. S. Lesage 2 Jeffery estate, Douglas Brown Sur, Young County, 50 bbl 41° grav 3919-36 ft Caddo. TD 3943 ft.

Thos. D. Humphrey 1 E. O. Chapman, H. Tidwell Sur, Haskell County, pumped & flowed 195 bbl in 12 hr 4240-315 ft. TD 5490 ft.

Gilcrease Oil Co. 6 W. W. Duson, I & G N Sur, Secs 23 & 24, Wharton County, 143 bbl 24.4° grav 4662-7 ft TD.

Gulf 421 E. Goldsmith, Sec 14 Blk 44, T & P Sur, Ector County, 5920 ft oil drillstem test 8020-40 ft Devonian Lime new zone.

Continental-Edge Oil Co. 1 Scott, T E & L Sur, Sec 3239, Clay County, pump 58 bbl 40° Ellenberger 6485-515 ft. TD 6515 ft.

Roger Lacy 1 Fee, Sec 22, Am. Rio Grande Co. sbdn, Hidalgo County, 75 bbl 34° 7983-92 ft, 9,600,000 gas 7455-65 ft. TD 10,771 ft.

Stanolind Oil & Gas Co. 1 C. L. Fisher, C SW SW 5-CL-EL & RR, Hale County, 558 bbl 40° oil 16 hr 6895-992 ft, Wolfcamp.

Delta Drilling Co. 1 Boynton, 2 mi E Mount Sylvan pool, Smith County, 283 bbl 33.3° oil 7512-28 ft Paluxy. TD 7727 ft.

Hinkle Drilling Co. 1 Miller-Vidor Ld. Co., J. M. Swisher Sur, Orange Co. oil 7772-8 ft. Hackberry. TD 7910 ft.

The Texas Co. 1 State-Amerada, Sec 106, Matagorda Bay, Calhoun County, 42 bbl 26.3° in 1 hr 20 min 4970 8 ft. TD 11,530 ft.

American Republic 1 TXL, C SW SE 7-45-1s, T & P Sur, Ector, pump 121 bbl 40° oil 7798-815 ft. TD 10,736 ft.

Warren Oil 1 B. Martin, M. DeWitt Sur, Young County, oil from 3522-9 ft Caddo Lime. Contract for 6000 ft test.

• **ILLINOIS.** W. O. Allen et al 1 F. S. Ackerman, NE NE SW 4-7s-10e, White County, 5 bbl in 1 hr 2897-913 ft. TD Aux Vases.

George Wickham 1 Broster, NW SE NE 34-25-14w, Cowling field, Edwards County, 150 bbl. New zone 2001-16 ft. TD Palestine sand.

Henry Smith & Associates 1 Hunt, NE 7-2s-10w, Gibson County, 30 ft on 1 hr drillstem test 1928-44 ft, new sand, Benoist. TD 1945.

• **LOUISIANA.** Humble 1 A. R. Romaine, 25-12s-1e, Vermillion Parish, 62 bbl 31.2° oil 11,066-80 ft. TD 12,482 ft.

Penrod Drilling 1 J. P. Mitchell, Catahoula Parish, pump oil and water 100,000 gas 9330-4 ft Tuscaloosa. TD 9471 ft.

Stanolind Oil & Gas 1 Ezeb Guillory, SW 29-6s-2e, Landry Parish, 80 bbl condensate 8952-58 ft. TD 9861 ft.

Gravis & Mitchell 2-J Natalbany, 12-9s-1e, Gabriel field, Iberville Parish, 209 bbl 39°. New zone 10,818-26 ft. TD 12,331 ft.

Continental 3-A Continental fee, 57-11s-6e, St. Martinville field, St. Martin Parish, 112 bbl 30°. New zone 4894-4902 ft. TD 8056 ft.

• **MISSISSIPPI.** California Co. 2 W. G. Greer, NW C NE ¼ 10-9n-4e, Jefferson County, 407,000 gas 1452-62 ft Cockfield. TD 2225 ft McBride dome.

Superior of Calif. 1 Cassie Bradford, SW SW NW 1-3n-13w, Forrest County, oil (reported). TD 15,730 ft, deepest in state.

• **NEW MEXICO.** Paul B. English & Byrd-Frost 1 Govt, C NW SW 4-27n, Kretz Canyon gas field, San Juan County. Drillstem 72° oil 4412-54 ft. TD 6483 ft.

Devonian Oil 1 Federal-Browne, 19-9s-38e, Lea County, swabbed 7 bbl in 1 hr 4945-5012 ft.

De Kalb Agriculture 1 N. T. Lewis, SE SW 13-10s-25e, Chaves County, pump 7 bbl 25° PB 1275 ft San Andres. TD 5650 ft.

• **KENTUCKY.** Fox & Fox 3 Grant, 14-P-28, Daviess County, pump 11 bbl 1488-1500 ft Jackson. TD 1515 ft.

• **KANSAS.** Skelly Oil 1 Allen, SE SE SW 22-11-19w, Ellis County, pump 323 bbl 3639-43 ft Arbuckle lime.

Kewanee Oil 1 Coombs, NE NE SE 5-30s-5e, Cowley County, pump 50 bbl 2851-3 ft Bartlesville. TD 2863 ft.

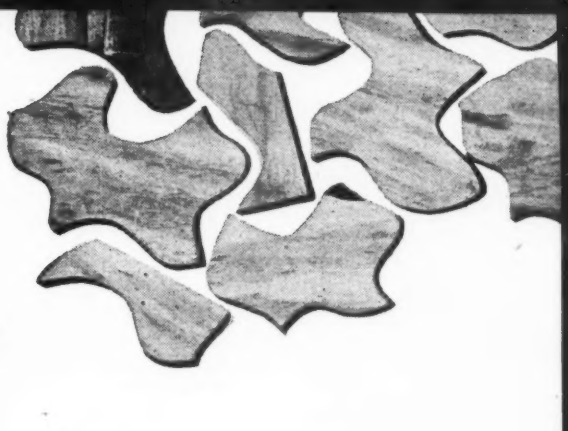
Bay Petroleum & H. H. & B. Drilling 1 Houdyshell, NE SE SW 31-20s-15w, Barton County, 1230 ft oil on drillstem 3844-50 ft Arbuckle.

• **WYOMING.** G. & G. Drilling 1 Govt, SE NE NW 19-45n-92w, Neiber Dome (Washakie County, 30 bbl in 5 hr. 10,025-55 ft Embar. TD 10,980 ft.

California Co. 2 Holst, SW NE SE 13-17n-77w, Quealy Dome, Albany County, swabbed 127 bbl in 8 hr 21.5° new zone Tensleep 5480-510 ft. TD 5654 ft.

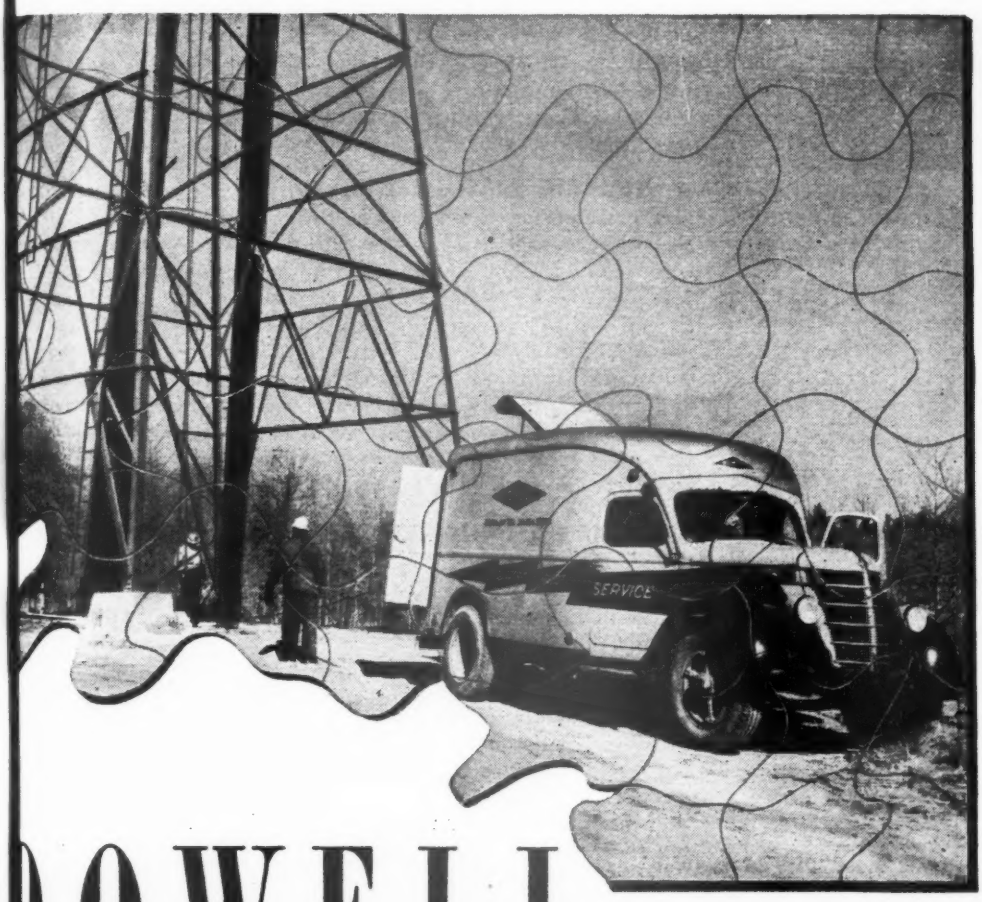
• **MICHIGAN.** Clawson Development 1 Talsma, C SW NE 2-5n-1w, Ottawa County, 325,000 cu ft gas. TD 906 ft.

Picture Puzzle?



Cores, samples and drilling logs are valuable "bits" and "pieces"—facts about your well. To fit the pieces together and to go beyond them—to supplement and multiply and correlate those facts—you need Dowell's Electric Pilot.

Put it together with THE ELECTRIC PILOT



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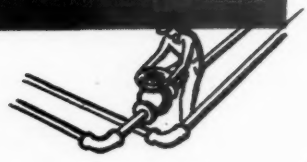


● **EXPANSION IN MIDDLE WEST LINES.** The Natural Gas Pipeline Company of America and Texoma Natural Gas Company have been authorized by FPC to construct additions to their gas transmission facilities operated as an integrated natural gas transmission system extending from the Panhandle field in Texas and supplying market areas in Indiana, Iowa, Kansas, Nebraska, Wisconsin and Illinois. The aggregate cost of the facilities is estimated at $23,493,987.

With the installation of these facilities, to be completed about January 1, 1949, Natural will have a capacity of about 484,000,000 cu ft to meet estimated peak day requirements.

Facilties authorized for construction by Texoma include nine 1250 units at a compressor station near Fritch, Texas, a 1500-hp compressor station in Moore County, Texas, about 10½ miles of 26-in. pipe line to complete the looping of its existing main transmission line and 15½ miles of 16-in. line extending to the gasoline plant of the Shamrock Oil and Gas Company, also in Moore County.

Natural Gas Pipeline will construct a 5000-hp compressor station near Hooker, Oklahoma; 39 compressor units, each of 1250-hp capacity, in existing stations; and approximately 110 miles of 24 and 26-in. main loop line.

● **FPC TO SIMPLIFY PROCEDURE.** The Federal Power Commission has announced it is taking steps to relax its controls over improvements and extensions of facilities by natural gas companies. The commission has received recommendations for a number of changes in the certificate procedures required of companies planning improvements or enlarging of their facilities. These are being submitted to the industry and will be followed by a formal commission order.

● **WEST VIRGINIA LINES.** Hope Natural Gas Company, Clarksburg, West Virginia, has FPC authorization to construct and operate additional natural gas transmission facilities in West Virginia at an estimated construction cost of $4,552,000.

Proposed facilities include three 800-hp compressor units at the Oscar Nelson compressor station and two 800-hp compressor units at the Loup Creek station in Wyoming County, two 1200-hp units at Jones station in Gilmer County, two 2000-hp units and one new boiler with 125,000 lb per hour capacity at Hastings station in Wetzel County, and an aggregate of 58 miles of 20-in. loop line paralleling existing main lines connecting 4 compressor stations.

● **MOUNTAIN PIPE LINE PROJECTED.** The Colorado Interstate Gas Company and the Canadian River Gas Company have filed with FPC a joint application for authorization to construct and operate facilities designed to increase the quantities of natural gas available to Denver and vicinity and to northern Colorado and Cheyenne, Wyoming. The companies have proposed two plans for construction, one of which would call for an initial outlay of $11,630,400 and the other an initial outlay of $15,224,000.

Under the first plan, which is contingent upon Colorado's ability to obtain a satisfactory gas supply in Hugoton field in Kansas, Colorado Interstate proposes to construct immediately a 20-in. line from the vicinity of Denver to near Holly in Prowers County, Colorado, a distance of about 207 miles. From this point, the company would construct a 16-in. line, approximately 50 miles in length, to a field compressor station at the Hugoton field. The line would provide a delivery capacity of approximately 84,000,000 cu ft a day.

In the event a sufficient gas supply cannot be secured from the Hugoton field, the alternate plan is for Colorado to lay about 268 miles of 20-in. line from Denver to the Texas-Oklahoma border from which point Canadian would continue the line for the 68 miles to Bivins station.

Colorado-Wyoming Gas Company, Denver, Colorado, has asked authorization to construct a new gas transmission pipe line from Denver to Cheyenne and a new compressor station on the proposed line. The application is contingent upon the approval by FPC of the application of Colorado Interstate Gas Company for the construction of an additional pipe line to Denver. Construction costs were estimated by the company at $1,415,000. Work on the project would begin in April, 1947.

● **PLANS GREATER FACILITIES.** United Fuel Gas Company, Charleston, West Virginia, has filed a request with FPC for authorization to construct and operate additional facilities in West Virginia to increase by approximately 41,000,000 cu ft per day the capacity of its existing facilities for delivery of natural gas to the Pittsburgh group of the Columbia Gas and Electric Corporation system. Cost was estimated at $2,970,000.

● **NEW BIG INCH PROTESTED.** The Big Inch Natural Gas Transmission Company has filed with FPC a protest to the amended application submitted by the Trans-Continental Gas Pipe Line Company, Inc., for authorization to build and operate a new pipe line for the transmission of natural gas from Texas to the eastern seaboard area of New York, New Jersey, Pennsylvania, Delaware, and Maryland. Estimated cost of the project is $130,000,000.

Big Inch Natural Gas asserts that the FPC should take no action with respect to Trans-Continental's amended application until after the War Assets Administration sells the Big and Little Big Inch lines.

● **SEEKS CANADIAN OUTLET.** Penn-York Natural Gas Corporation of Buffalo, New York, has requested authority to construct and operate a pipe line to transport and sell natural gas to the Dominion Natural Gas Company, Ltd., of Ontario, Canada.

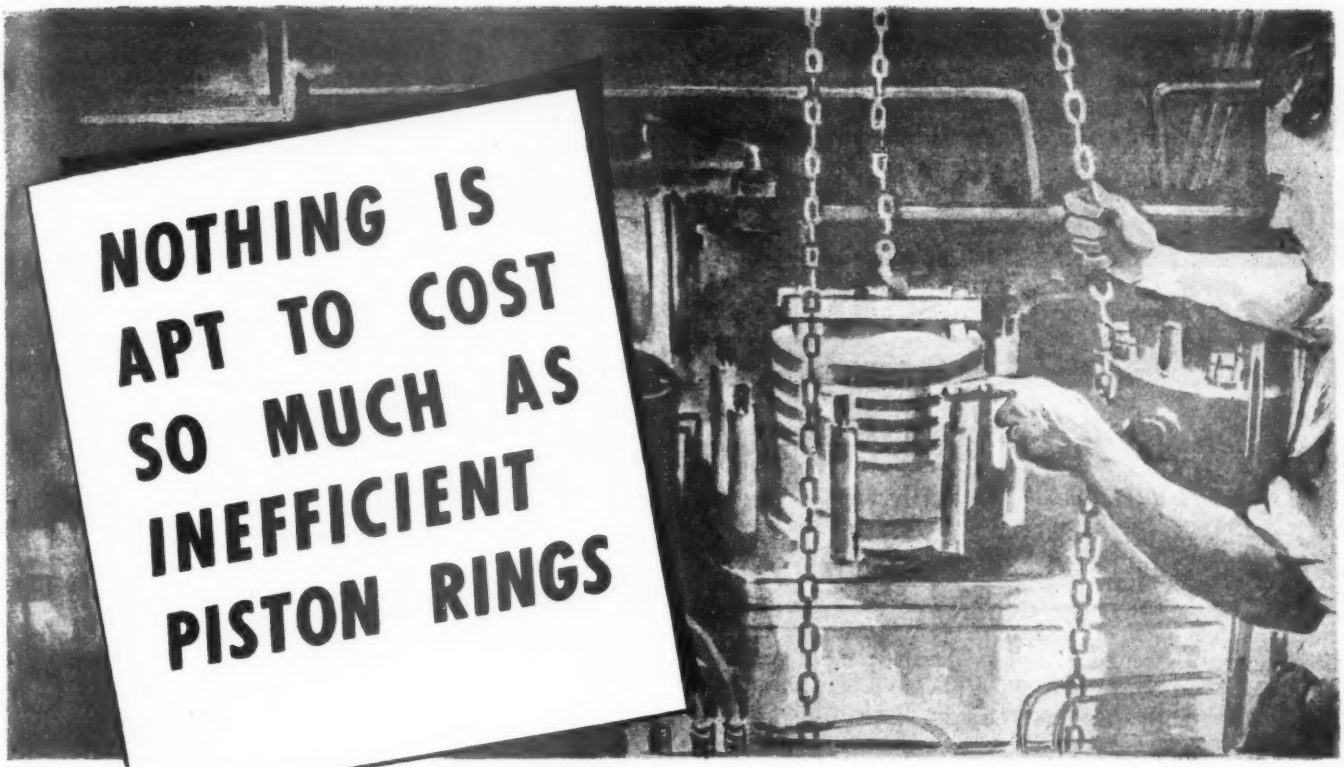
Proposed facilities include construction of a pipe line with diameter ranging from 14 to 10¾ in. which will run from York, New York, to a point on the Niagara River, a distance of about 65 miles; and a 1200-hp compressor station on the proposed line. The over-all cost was estimated at $1,235,610.

● **MORE NEWS.** Humble Pipe Line Company began construction of a 43-mile 6-in. line from the Pittsburg pool, East Texas, to Longview. The line will have a daily capacity of 10,000 bbl.

Sunray Oil Corporation has completed 12 miles of 4-in. crude pipe line from the new Albright pool to a line connecting with the company's refinery at Allen.

Shell Pipe Line Company plans a $1,250,000 six-inch pipe line from its Sheridan cycling plant in Colorado County, to the Deer Creek refinery, near Houston, a distance of some 100 miles.

Chicago District Pipeline Company will construct 11 miles of 24-in. gas pipe line to complete the looping of its Crawford line extending from the vicinity of Joliet, Illinois, to a connection with the facilities of The Peoples Gas Light and Coke Company at the western city limits of Chicago, Illinois. Cost has been estimated at $750,000.



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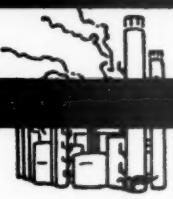
refining and natural gasoline activities



● **LARGEST EUROPEAN NG UNIT.** Hudson Engineering Corporation, Houston, Texas, has a contract for designing and purchasing material for the largest natural gas plant ever constructed in Europe. The new plant will be constructed in the St. Marcet gas condensate pool in southwestern France about 30 miles north of the Spanish border and about half way between the Bay of Biscay and the Mediterranean coast. The project will cost about $2,000,000. The gas pool, owned by the French government, and operated by Regie Autonome des Petroles, a government-owned company, was discovered before the war. Fourteen wells have been drilled there with 11 now productive.

The new plant will process 60,000,000 cu ft per day, extracting from the gas the heavier hydrocarbons from which five liquid products, propane, butane, motor fuel, naphtha, and kerosene, will be produced. The gas remaining after the extraction of these products will be piped north to the city of Toulouse, and west to the cities of Pau and Tarbes, where it will be used as industrial fuel and as a base for the manufacture of chemicals.

The Hudson Company was engaged by the French company several months ago to develop complete process and mechanical design of the plant, as well as to purchase the necessary equipment and supervise construction. Construction is expected to start in the next few months.

The Hudson Engineering Company specializes in such work, having designed similar plants for the North Houston, La Gloria, Cotton Valley, Alice, West Ranch, Cranfield, Lake St. John, Long Lake and other pools in the United States.

● **WAA STYRENE UNIT SOLD.** The Dow Chemical Company has purchased from the War Assets Administration of the government the styrene plant at Velasco, Texas. The sale price was $35,155,000, it is said.

Dr. Willard H. Dow, company president, said styrene is "one of the two major raw materials of the synthetic rubber industry." He added that "while buna requirements are gradually diminishing, roughly three-fourths of the Velasco plant production will go to the rubber reserve for an indefinite period."

In addition to the styrene plant, Dow also acquired a portion of the Velasco magnesium plant, including the lime, chlorine, and power facilities. The actual metal producing units were not in the purchase and are to be held in standby conditions for the government.

● **POSTPONE TEST PROJECT.** A joint federal agency project to conduct extensive road tests on gasoline to determine sulphur content limits in federal specifications has been postponed until next year, according to a National Petroleum Association report.

Plans for the elaborate tests could not be completed in time for trials this winter. Among the federal agencies participating in the plan are the National Bureau of Standards and the War Department. The Bureau of Standards is doing extensive block testing of gasoline samples and studying results of Canadian tests in the far north.

● **SEARLE EXTENDS INTERESTS.** Searle Petroleum Company of Omaha, Nebraska, has purchased the Salem, Nebraska refinery of Oil Marketing and Refining Company, Inc., a move that will double the Searle company's present refining capacity, according to announcement by H. A. Searle, Jr., president.

The purchase involves additional crude supply and tankcars for the Searle interests. John Peters, one of the owners of the purchased property, will devote his attention to new production development. New activity now is under way looking to possible expansion of Nebraska crude oil production, through test wells in new territory, including some exploration of deeper possibilities.

● **RFC CLOSES PLANT.** The butadiene plant at the Sun Oil Company's refinery on Woodville Road, East Toledo, Ohio, was shut down on orders of the Reconstruction Finance Corporation. Two hundred employes will be laid off, officials said. The plant is owned by the government and has been operated by the Sun Oil Company as agent.

Using a petroleum catalytic dehydrogenation process which Sun Oil engineers helped develop, the butadiene plant represents an investment by the Defense Plants Corporation of approximately $7,400,000. The plant has produced about 40,000,000 lb of butadiene from butane for the synthetic rubber program since it was put into production in 1944.

● **BUYS CANADIAN PLANT.** Trinidad Leaseholds, Ltd., of London, England, announces it has acquired the capital stock of Good Rich Refining Company, Ltd., with refinery at Fort Credit, Toronto, Canada. The president of the company will be C. C. Johnstone and the vice president, Reuben Rosefield. They will also be joint managing directors.

The purchase of Good Rich Refining Company is a step in the expansion of the activities of Trinidad Leaseholds into the Dominion of Canada, where the complementary resources of the Toronto and Trinidad refineries may be integrated.

Trinidad Leaseholds is associated with the Central Mining and Investment Corporation, Ltd., one of the leading finance corporations in England, with extensive interests in South Africa. This corporation also has substantial petroleum interests in Venezuela.

● **OPERATOR ACQUIRES PLANT.** Sid W. Richardson, Fort Worth, Texas, oil producer, has purchased the American Liberty Oil Company refinery at Texas City, on the Houston ship channel, for a reported price of $2,500,000. Sale was effective February 1.

Richardson has formed the Sid Richardson Refining Company with Freeman W. Burford, Dallas, as president. Headquarters of the new company will be in Dallas.

The American Liberty Oil Company acquired the plant, which has a skimming capacity of 20,000 bbl. daily and 3000 bbl. cracking capacity, in 1938 through absorption of Southport Petroleum Company. Richardson plans to supply the plant from his properties in West Texas, where he is a large operator.

● **MISCELLANEOUS.** Crown Prince Saud Al-Saud of Saudi Arabia, and his party, on a tour of the United States, spent part of his time visiting American oil refineries in which he showed particular interest.

Fire destroyed the Hickok Oil Company bulk plant outside of Toledo, Ohio. Five fire departments fought the blaze.

Premier Oil Refining Company, Longview, Texas, has purchased a half interest in the Arp refinery of the Independent Refining Company and has taken over operation of the unit.

Southland Oils, Inc., Dallas, Texas, has purchased a refinery at Laurel, Mississippi, and plans to spend $150,000 in repairs and expansions. A. A. Spencer is president of Southland.

THE Petroleum Engineer

FEBRUARY, 1947

Bulk of new oil reserves discovered in 1946 were additions to developed fields

By H. J. STRUTH,* *Petroleum Economist*

CRUDE oil production of the United States in 1946 broke all records, aggregating 1,731,480,000 bbl, but the search for new petroleum reserves increased the proved underground inventory of oil by only 323,520,000 bbl. Discoveries of oil in new pools, extensions of previously discovered oil pools, and upward revisions of previous estimates added a total of 2,055,000,000 bbl to the nation's proved petroleum reserves. However, discoveries credited to previous finds through extensions and revisions accounted for 84 per cent of the total. The result of last year's credit balance brought the nation's proved reserves to a total on January 1, 1947, of 21,177,000,000 bbl.

EXCLUSIVE

The year 1946 was probably the most costly period in the oil industry's history. The average cost per well incurred by exploratory operations, including all expenditures chargeable thereto, was $77,400, compared with an average total cost in 1935 of $31,000. The average cost of drilling an exploratory well, including dry holes, was $59,300, compared with an average cost in 1935 of $11,000. Expenditures of the industry for exploration in 1946 aggregated $837,558,000, compared with $162,259,000 in 1935. Thus, whereas the finding cost of new oil discovered in 1935 was 15.5 cents per bbl, the cost of finding a bbl of new oil in 1946 was 53.6 cents.

The salient figures for 1946 are shown in Table 1. The measurement of finding cost is made by dividing the sum of all oil discoveries in new fields and extensions to previously discovered fields into the total expenditures incurred by exploration. Revisions in previouns estimates are not included in the divisor, but are credited to prior periods. Thus, the net discoveries in 1946, exclusive of revisions in previous estimates, are placed at a total of 1,830,000,000 bbl. This compares with 1945 discoveries of 1,861,000,000 bbl, for which the initial finding cost was 49.5 cents per bbl.

TABLE 1. 1946 exploratory expenditures (preliminary estimates).

Drilling cost—including equipment of productive wells	$ 425,208,000
Cost of acquiring and carrying leases, including land departments	276,500,000
Geological and geophysical cost	70,350,000
Overhead and general office expense	65,500,000
Grand total	$ 837,558,000
Total exploratory wells drilled*	10,805
Average drilling cost per well	$ 39,300
Average total cost per well	$ 77,400
Reserves discovered:—(bbl)	
New fields	326,000,000
Extensions to previously discovered fields†	1,504,000,000
Total discoveries	1,830,000,000
Working interest (85.5 per cent)	1,565,000,000
Initial cost per barrel	$ 0.536

*Includes productive wildcats and all dry holes drilled in undeveloped and developed areas.

†Does not include revisions in previous estimates aggregating about 225 million barrels.

Note: Costs shown are proportions charged to exploration only. They do not include costs chargeable to developed leases nor costs of drilling oil and gas wells in proved producing areas.

Highly significant to the future outlook of the United States, with respect to the maintenance of an adequate oil supply, is the conclusion drawn by these studies: That it takes a period of eight years to measure the full effect or the ultimate size of new oil field discoveries. Reserves discovered by wildcat operations in 1946 are initially estimated at only 326,000,000 bbl, but it will take a period of eight years to determine the full extent of these discoveries by subsequent extensions and revisions of first estimates.

Reserves added by extensions and revisions in 1946 aggregated about 1,729,000,000 bbl, but credits of this oil to previously discovered fields were found to extend back to the year 1938. Thus, whereas the initial estimates of reserves discovered in 1938, credited to new fields, amounted to 810,000,000 bbl, subse-

*Editor, *The Petroleum Data Book.*

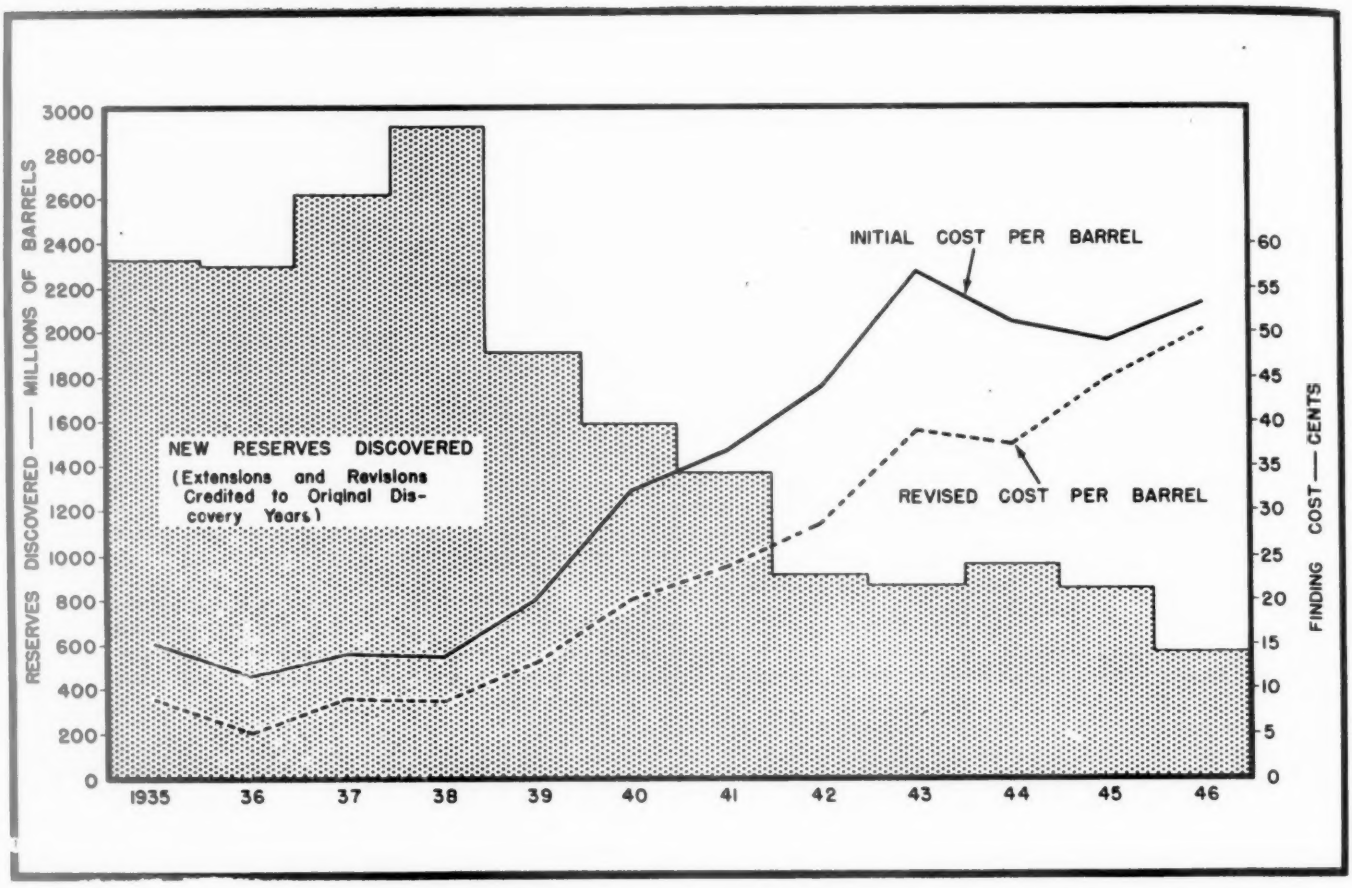


FIG. 1. Smaller annual revisions in first estimates reduce margin between initial and revised costs. (See Table 2)

quent extensions and revisions, down through 1946, added 2,110,000,000 bbl to the original discoveries. In the eight years, 1938-45, new reserve discoveries aggregated 3,340,000,000 bbl, whereas extensions and revisions allocated to original discoveries during this period, including such oil added in 1946, have amounted to over 8,000,000,000 bbl.

The effect of continual back credits for annual discoveries by extensions and revisions is to reduce oil finding costs, as shown in Table 2. It will be noted that the initial finding cost per bbl in 1943 was 57.1 cents; however, subsequent extensions and revisions credited to 1943 discoveries had the effect of reducing the cost per bbl to 39.3 cents. Although the initial cost of finding oil in 1946 was 53.6 cents per bbl, near-future credits by extensions and revisions are shown by projection to lower the cost to perhaps 50.5 cents per bbl. Combined finding costs for 4-year periods show the effect of annual credits to original reserve discoveries. During the last four years the average finding cost was 52.5 cents, whereas actual and projected revisions have the effect of reducing the average cost to 44 cents per bbl. Compared with the years 1935-38, effort to find reserves by exploration (during the last four years) has increased 50 per cent, while expenditures for exploration have increased 223 per cent and results, as measured by revised discoveries, have shown a decline of 41 per cent. These facts explain recent crude oil price increases and point to the possibility of a further upward price adjustment in the near future.

Replacement cost of petroleum reserves is a factor of vast importance to the petroleum industry. Table 3 presents data showing the effect of constantly increasing costs upon replacement values. Between 1935 and 1940 the petroleum industry discovered, by ultimate effect of extensions and revisions, a total of 13,691,000,000 bbl of crude oil. During this period, productive requirements aggregated 7,204,000,000 bbl. The result was

TABLE 2. Approximate cost of finding oil in the United States. (Barrels in millions—money in thousands). (Revised 1946).

Year	Initial reserves discovered (a)	Working interest (85.5%) (b)	Revised reserves discovered (c)	Working interest (85.5%) (d)	Exploratory wells and dry holes drilled (e)	Total drilling cost (f)	Lease and overhead cost (g)	Total cost (h)	Initial cost per bbl (cents) (h÷b)	Revised cost per bbl (cents) (h÷d)	Average cost per well: Drilling (f÷e)	Average cost per well: Total (h÷e)
1935	1,220	1,043	2,050	1,753	5,231	$ 57,639	$104,620	162,259	15.5	9.3	$11,000	$31,000
1936	1,763	1,507	3,770	3,223	5,671	63,414	113,420	176,834	11.9	5.6	11,400	31,200
1937	1,929	1,649	2,975	2,544	6,900	85,320	151,800	237,120	14.3	9.3	12,300	34,400
1938	1,854	1,585	2,870	2,454	6,453	81,750	141,966	223,716	14.1	9.1	12,600	34,700
1939	1,450	1,240	2,211	1,890	6,732	90,177	161,568	251,745	20.3	13.3	13,400	37,400
1940	1,020	872	1,616	1,382	7,032	102,644	182,832	285,476	32.7	20.3	14,600	40,600
1941	980	838	1,525	1,304	7,388	125,075	185,221	310,296	37.0	24.0	17,000	42,000
1942	779	666	1,210	1,035	6,123	121,302	172,602	293,904	44.1	28.8	19,800	48,000
1943	862	737	1,242	1,062	6,703	169,222	252,140	421,362	57.1	39.3	25,100	62,860
1944	1,231	1,052	1,681	1,437	7,757	246,516	294,983	541,499	51.5	37.8	31,800	71,500
1945	1,861	1,591	2,030	1,736	10,399	392,085	392,152	784,237	49.5	45.0	37,900	75,400
1946*	1,830	1,565	(u)1,940	1,659	10,805	425,208	412,350	837,558	53.6	(s)50.5	39,300	77,400
Summary—four-year totals												
1935-38	6,766	5,784	11,665	9,974	24,255	288,123	511,806	799,929	14.5	8.0	11,800	32,800
1939-42	4,229	3,616	6,562	5,611	27,275	439,198	702,223	1,141,421	31.6	21.8	16,100	41,900
1943-46	5,784	4,945	6,893	5,894	35,664	1,233,031	1,351,625	2,584,656	52.5	44.0	34,600	72,500

(a) New field discoveries and extensions to previously discovered fields. (Revisions allocated to back years.)
(c) Includes subsequent revisions in first estimates.
(e) Wildcat producers and all dry holes drilled in exploration and development.
(f) Costs include equipping wildcat producers.
(g) Includes cost of leases, geological, geophysical expense and overhead costs.
(s) Projected to include effect of subsequent upward revisions in first estimates.
(u) Provides for subsequent upward revision in first estimates.
*Preliminary.

TABLE 3. Replacement cost of petroleum reserves. (Revised 1946).

Year	New reserves discovered (million)†	Crude oil produced (million)	Surplus or short (million)	Working interest (85.5%) (million)	Adjusted finding cost per bbl	Total finding cost (thousands)
1935	2,325	997	+1,328	+1,133	$ .093	$105,369
1936	2,305	1,100	+1,205	+1,030	.056	57,680
1937	2,629	1,278	+1,351	+1,155	.093	107,415
1938	2,920	1,213	+1,707	+1,459	.091	132,769
1939	1,916	1,264	+ 652	+ 557	.133	74,081
1940	1,596	1,352	+ 244	+ 209	.203	42,427
Total period of surplus	13,691	7,204	+6,487	+5,543	.092	519,741
1941	1,375	1,404	— 29	— 25	.240	6,000
1942	925	1,385	— 460	— 393	.288	113,184
1943	872	1,503	— 631	— 540	.393	212,220
1944	974	1,678	— 704	— 602	.378	227,556
1945	855	1,711	— 856	— 732	.450	329,400
1946 (P)	576*	1,731	—1,155	— 988	.505	498,940
Total period of shortage	5,577	9,412	—3,835	—3,280	.423	1,387,300
Future to balance	....	....	—2,652	—2,263	.505	1,142,815
Projected total	....	....	—6,487	—5,543	.456	2,530,115

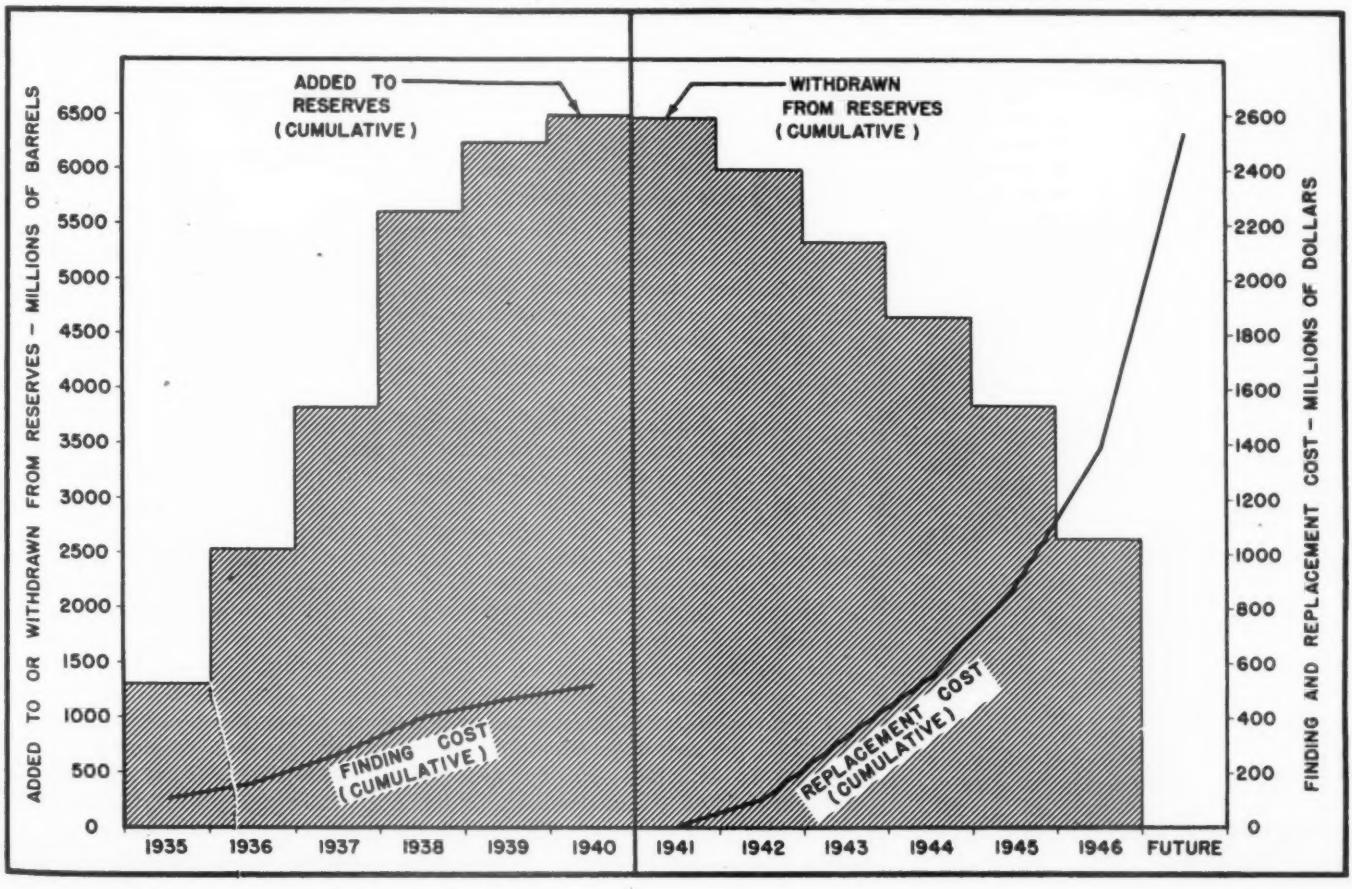
†Extensions and revisions credited to original discovery year.
*Provides for subsequent upward revision of about 250 million barrels.
(P)–Preliminary.

an accumulation in the underground inventory of reserves aggregating 5,543,000,000 bbl. Expenditures incurred for exploration during this period amounted to $519,741,000, or 9.2 cents per bbl. Between 1941 and 1946 discoveries aggregated 5,577,000,000 bbl, while production was 9,412,000,000 bbl. This resulted in net withdrawals from proved reserves of 3,290,000,000 bbl, which entailed replacement expenditures of $1,387,300,000, or an average of 42.3 cents per bbl. If the present trend continues, it is likely that the industry will consume the remainder of the surplus reserves accumulated in the earlier period. If this remainder is withdrawn from reserves, at the 1946 revised cost of 50.5 cents per bbl, the ultimate cost of replacement would total $2,530,115,000, or an average of 45.6 cents per bbl, a cost five times as great as that required to find those reserves accumulated between 1935 and 1940.

By allocating to years of original discovery all reserves found each year by extensions and revisions, it reveals that the peak level of proved reserves was established at the end of 1940. Reserves reported December 31, 1940, were 19,024,000,000 bbl, but subsequent extensions and revisions to discoveries resulted in credits to back years, which raised the reserve inventory to 25,012,000,000 bbl. Thus, instead of increasing proved reserves in the last six years to the extent of 2,153,000,000 bbl, actual depletion of the underground inventory was 3,835,000,000 bbl. By crediting subsequent extensions and revisions to original discovery years, it is possible to measure the full effect of annual discoveries. Table 4 shows the results of such allocations from 1916 through 1946 with projections of probable revisions of 1946 discoveries. The proved reserve inventory on January 1, 1947, was 21,177,000,000 bbl by either method of calculation, but the history of discoveries and proved reserves is decidedly changed from the conventional method of currently crediting all discoveries, extensions, and revisions.

The East Texas field is a conspicuous example of the effect of allocating subsequent extensions and revisions to years of original discovery. Early estimates placed reserves of this area at about 600,000,000 bbl. For several years after this discovery in 1930, it was necessary to make substantial upward revisions in reserves because of subsequent extensions and revisions. As a result, reserves of the East Texas field ultimately attained a total of over 5,000,000,000 bbl,

FIG. 2. Replacement costs are five times greater than prewar years. (See Table 3)



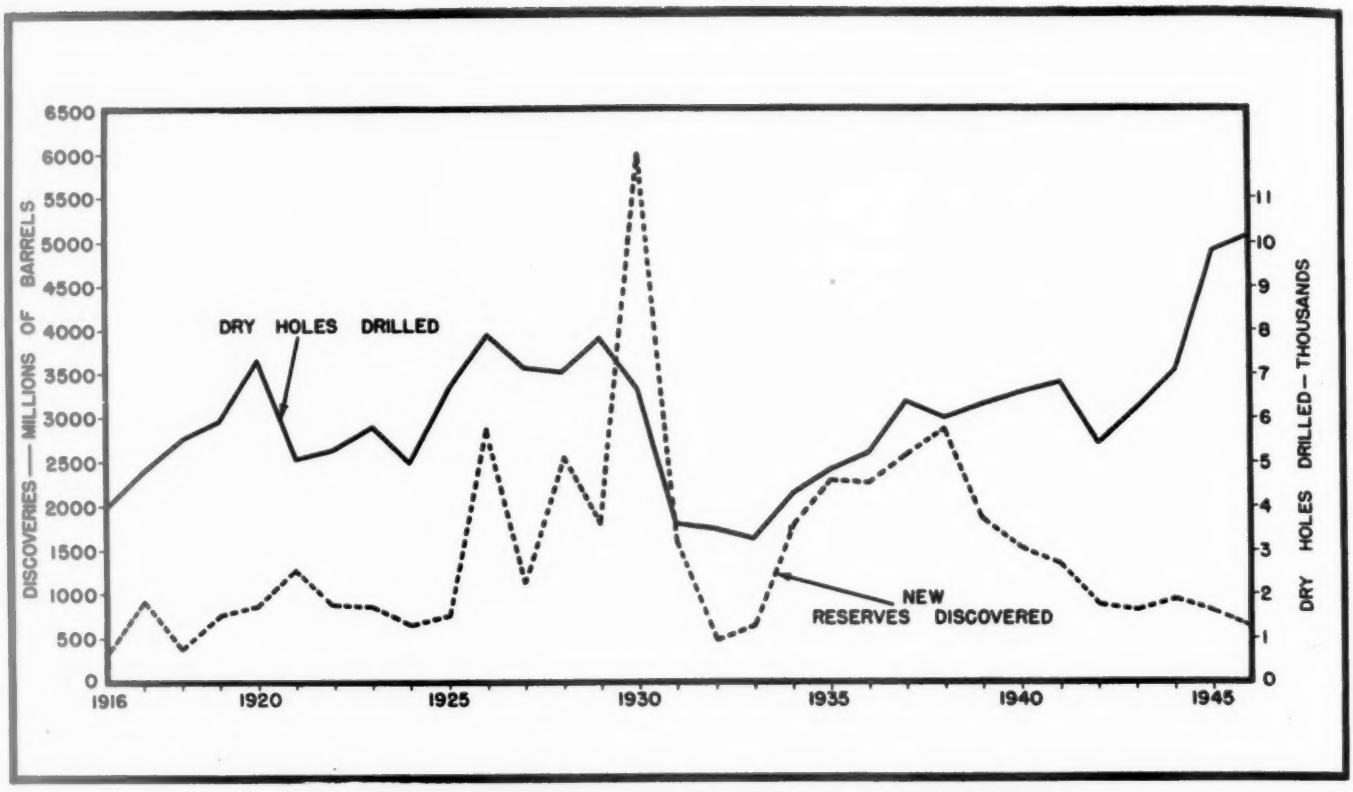


FIG. 3. More dry holes—smaller net discoveries is trend. (See Table 4)

whereas the original discovery was credited with only about 600,000,000 bbl. Although subsequent extensions and revisions resulted from succeeding exploratory activities, it is obvious that the original discovery well provided the impetus to continue exploration to define the maximum limits of the productive area. All subsequent extensions to this field were the end result of the initial discovery.

The period 1926-30 was the most successful in point of reserve discoveries in the industry's history. In that period the industry actually found 14,350,000,000 bbl of new reserves, although it took at least eight years following the original discoveries to attain the maximum ultimate quantity of reserves available by production. By comparison, reserves credited to discoveries made in the last six years have aggregated only 5,577,000,000 bbl. In the five years, 1941-45, reserves discovered have averaged about 1,000,000,000 bbl annually. In 1946, subject to ultimate upward revision, but projecting probable subsequent additions, the industry could only claim credit for the net discovery of about 576,000,000 bbl of new reserves.

Over a period of 23 years, excluding the five-year period 1926-30, which embraced the discovery of Kettleman Hills, Oklahoma City, and East Texas, the average ratio of reserves to production was 1.66. Over the last eight years the average ratio of reserves to production was only 0.75. As we discovered during the latter period an annual average of 1,136,000,000 bbl and produced annually 1,506,000,000 bbl, it is apparent that by application of the former ratio experience of 1.66, annual discoveries of the last eight years have fallen short of requirements by more than 1,300,000,000 bbl. Present and prospective market demand for crude oil produced in the United States dictates the need for annual, ultimate discoveries of reserves in the order of about 2,500,000,000 bbl. Although the ultimate significance of new oil discoveries of the last eight years cannot be accurately and fully predetermined, it is evident from data now available, by studies of allocation trends, that subsequent extensions and revisions will not attain the ultimate effect of annual discovery rates of 2,500,000,000 bbl.

A highly favorable factor to the successful search for new oil reserves is the sharp upward trend in exploratory operations. Despite extremely high costs, the search for new reserves is being pursued with increasing vigor in every section of the nation. An infallible index of exploratory effort is the number of dry

Senate oil committee reports

A special Senate committee made a recent report, submitted by Chairman Joseph C. O'Mahoney (Dem.) of Wyoming and signed by all members of the eleven-man petroleum committee, demanding that any petroleum policy make certain the United States would not become dependent upon any other country for its supplies of liquid fuel.

The committee recommended a broad national petroleum program that would:

1. Expand production of synthetic liquid fuels.
2. Adjust tax structures to allow independent operators to plow back into their business enough profit to make prospecting for new domestic supplies worthwhile.
3. Closer co-ordination of government and corporate relationships in the field of foreign oil developments by American companies.

The report pointed out that this nation was no longer the world's greatest reservoir of oil, saying that less than one-third of known reserves were located in the continental United States. Discoveries of new fields in the last ten years had been decreasing in size and importance, while other world fields were larger and more numerous on the basis of recent discoveries.

Admitting that American-owned shares of foreign reserves had grown from 22.7 per cent of an estimated 9,175,000,000 potential foreign barrels in 1928, to 46.3 per cent of the estimated 37,554,000,000 bbl of known deposits in 1945, the committee said the nation could not rely for delivery of that supply from abroad if under attack, but must rely on its home industry.

TABLE 4. Dry holes, reserves discovered, production (1916-1946 inclusive).

Year	Dry holes drilled	New reserves discovered (mill bbl)†	Dry holes per mill bbl	Annual production (mill bbl)	Surplus or short (mill bbl)	Reported reserve inventory (mill bbl) (Dec. 31) (a)	Adjusted reserve inventory (mill bbl) (Dec. 31)
1916	4,039	250	16	301	— 51	5,900	5,242
1917	4,851	950	5	335	+ 615	5,900	5,857
1918	5,631	400	14	356	+ 44	6,200	5,901
1919	5,986	800	7	378	+ 422	6,700	6,323
1920	7,346	900	8	443	+ 457	7,200	6,780
Total 5 years	27,853	3,300	..	1,813	+1,487		
Annual average	5,571	660	8	363	+ 297		
1921	5,160	1,300	4	472	+ 828	7,800	7,608
1922	5,332	900	5	557	+ 343	7,600	7,951
1923	5,883	900	6	732	+ 168	7,600	8,119
1924	5,044	700	7	714	— 14	7,500	8,105
1925	6,734	800	8	764	+ 36	8,500	8,141
Total 5 years	28,153	4,600	..	3,239	+1,361		
Annual average	5,631	920	6	648	+ 272		
1926	7,965	2,900	4	771	+2,129	8,800	10,270
1927	7,210	1,100	6	901	+ 199	10,500	10,469
1928	7,078	2,550	3	901	+1,649	11,000	12,118
1929	7,914	1,800	4	1,007	+ 793	13,200	12,911
1930	6,734	6,000	1	898	+5,102	13,600	18,013
Total 5 years	36,901	14,350	..	4,478	+9,872		
Annual average	7,380	2,870	2	896	+1,974		
1931	3,659	1,600	2	851	+ 749	13,000	18,762
1932	3,569	500	7	785	— 285	12,300	18,477
1933	3,312	700	5	906	— 206	12,000	18,271
1934	4,312	1,800	2	908	+ 892	12,177	18,525
1935	4,911	2,325	2	997	+1,328	12,400	19,853
Total 5 years	19,763	6,925	..	4,447	+2,478		
Annual average	3,953	1,385	2	889	+ 495		
1936	5,296	2,305	2	1,100	+1,205	13,063	21,058
1937	6,420	2,629	2	1,278	+1,351	15,507	22,409
1938	6,043	2,920	2	1,213	+1,707	17,348	24,116
1939	6,357	1,916	3	1,264	+ 652	18,483	24,768
1940	6,617	1,596	4	1,352	+ 244	19,024	25,012
Total 5 years	30,733	11,366	..	6,207	+5,159		
Annual average	6,147	2,273	3	1,241	+1,032		
1941	6,885	1,375	5	1,404	— 29	19,589	24,983
1942	5,532	925	6	1,385	— 460	20,083	24,523
1943	6,266	872	7	1,503	— 631	20,065	23,892
1944	7,149	974	7	1,678	— 704	20,454	23,188
1945	9,858	855	12	1,711	— 856	20,853	22,332
Total 5 years	35,690	5,001	..	7,681	—2,680		
Annual average	7,138	1,000	7	1,536	— 536		
1946 (P)	10,208	576*	18	1,731	—1,155	21,177	21,177
Total 6 years	45,898	5,577	..	9,412	—3,835		
Annual average	7,650	929	8	1,569	— 740		

†Extensions and revisions credited to years of original discovery.

*New discoveries accounted for about 326 million barrels. Provides for subsequent upward revision of about 250 million barrels.

a—Reported by A.P.I. Committee on reserves—1946 estimated by author. (P)—Preliminary

holes drilled in attempts to develop new production in proved and unproved areas. In the last six years, the industry drilled 45,898 dry holes, the largest number ever drilled in any similar period. In 1946, a total of 10,208 dry holes was drilled in the search for production, which is the largest number drilled in any year to date.

In 1946 the industry drilled 28,656 wells, of which 10,208 were dry holes. This is 35.6 per cent, which compares with an average of 31.1 per cent in the preceding five years and an average of 22.3 per cent dry in the five years ending with 1940. The large number of dry holes drilled in the last two years may be the result of wide spacing regulations in the various states. It is quite possible that these regulations may have forced drilling outside of the limits within which production might have been developed and resulted in dry holes instead of producers. If spacing regulations were revised in the various oil states, there might possibly be a substantial decrease in the number of dry holes drilled. Obviously, the drilling of such a large percentage of dry holes adds greatly to the cost of finding oil.

An important consideration in this respect is the fact that it took 18 dry holes in 1946 to lead to the discovery of a million bbl of new reserves. The annual average over the last six years has been eight dry holes for each million bbl of oil discovered. This compares with an average of two dry holes drilled per million bbl of oil discovered between 1934 and 1938. In 1930 when the East Texas oil field was discovered, one dry hole was drilled per million bbl of new oil discovered. At present the average cost of a dry hole is about $33,000 and that being so the cost becomes almost prohibitive. During the last six years the industry found 121,000 bbl of new oil for each dry hole drilled, whereas in the five years ending with 1940 discoveries per dry

FIG. 4. First estimates and revisions in reserve discoveries converging. (See Table 2)

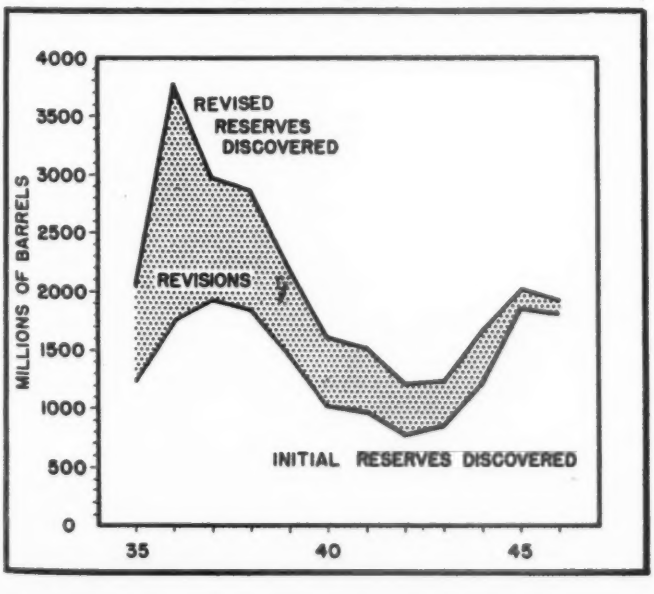
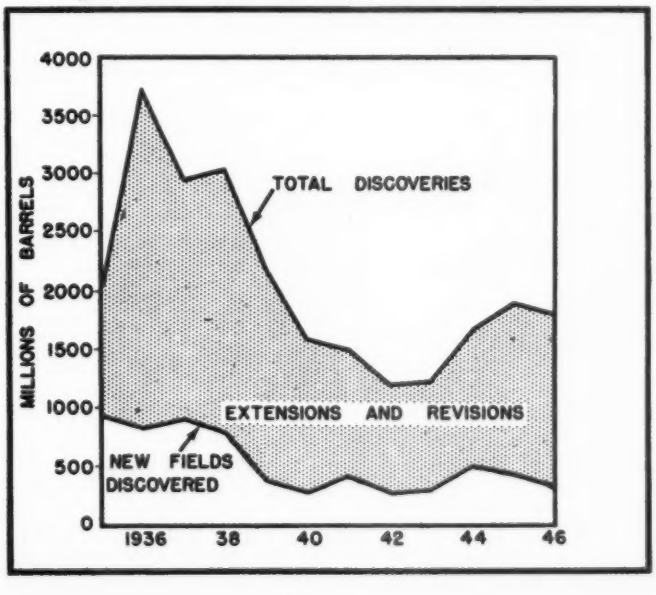


FIG. 5. Extensions and revisions provided 84 per cent of 1946 discoveries. (See Table 6)



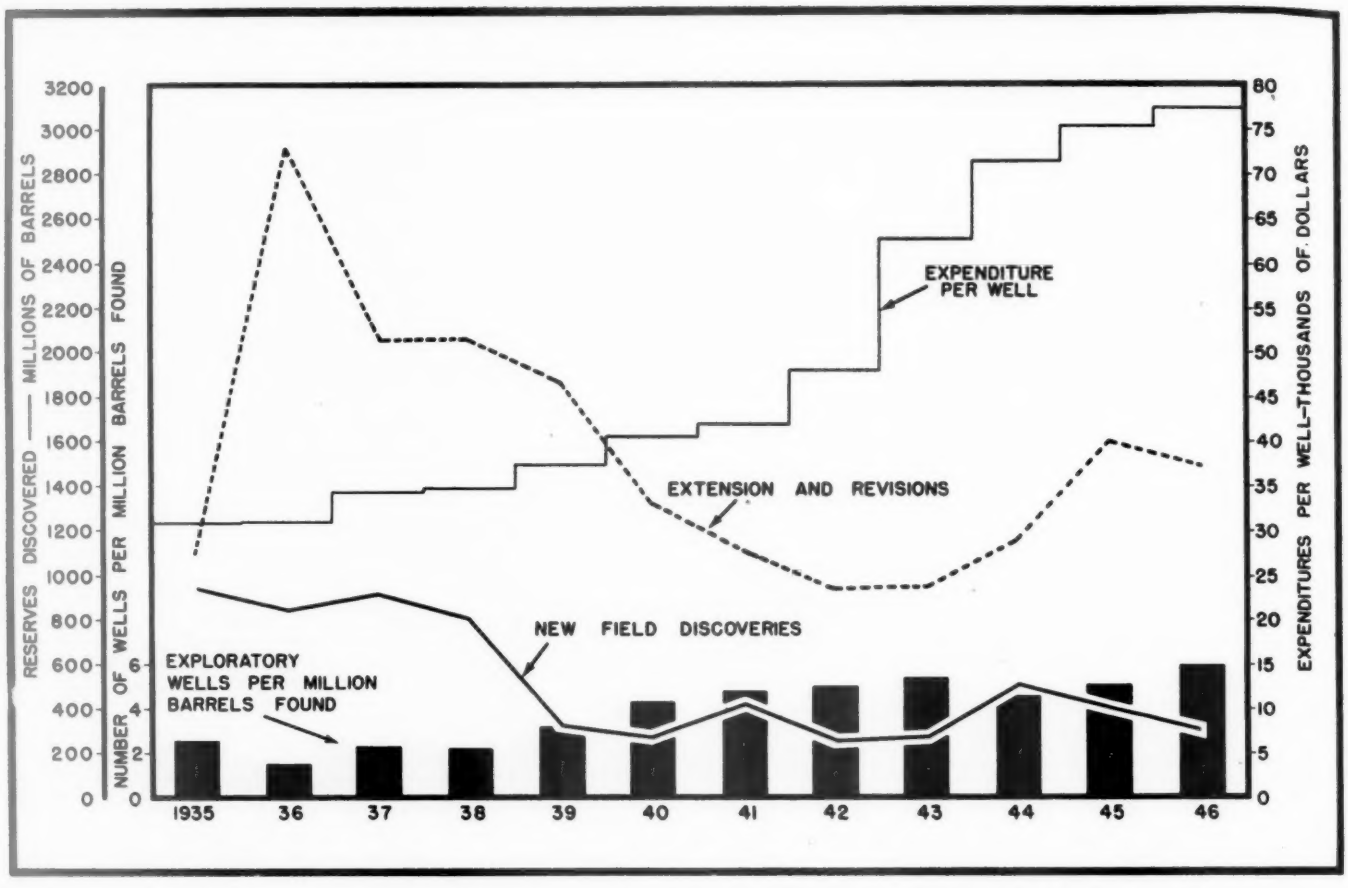


FIG. 6. More wells needed to discover new reserves at constantly greater cost. (See Tables 2, 6, and 9)

hole averaged 370,000 bbl, and in the five years ending with 1935 the average discovery per dry hole was 473,000 bbl.

It is of interest to note that the average quantity of oil discovered per wildcat producer completed in 1946 was 704,000 bbl, which compares with an average of 1,381,000 bbl in 1944. Table 5 shows that although the results of exploration through wildcat operations have not been too encouraging, it is decidedly heartening to find that extension drilling in previously discovered areas is meeting with greater success than has been shown over the last several years. In 1946 the average quantity of oil discovered through extension drilling was 11,224,000 bbl per well, whereas in 1944 the average per well by extension drilling was 6,372,000 bbl. Composite results of all wildcat drilling show that an average of 3,065,000 bbl of oil per well was discovered in new fields and extension drilling, which compares with 2,549,000 bbl per well in 1944.

The result of exploratory effort, presented in Table 6, emphasizes the difficulties that have confronted oil operators in recent years. In 1946 it was necessary to drill nearly six exploratory wells to find a million bbl of new reserves, whereas in 1936 it took less than two exploratory wells to find a million bbl of reserves. In 1936 an average of 665,000 bbl of new reserves were discovered for each exploratory well drilled, whereas in 1946 an average of only 169,000 bbl of new oil

TABLE 5. Drilling and exploratory results, 1944-1946.

	1946(P)	1945	1944
Oil wells (new disc. incl. new pays)	463	427	380
Oil wells (extensions)	134	114	113
Gas wells	125	130	115
Dry holes	3,581	3,434	3,240
Total wildcats	4,303	4,105	3,848
Development dry holes	6,627	6,424	3,909
Total exploratory wells	10,930	10,529	7,757
Development oil wells	14,813	13,921	12,698
Development gas wells	2,913	2,595	2,198
Total wells drilled	28,656	27,045	22,653
Discoveries			
Oil wells completed	463	427	370
New oil discovered (millions)	326	420	511
Average per well (thousands)	704	984	1,381
Extensions*			
Oil wells completed	134	114	113
New oil discovered (millions)	1,504	1,441	720
Average per well (thousands)	11,224	12,640	6,372
Composite (wildcats)			
Oil wells completed	597	541	483
New oil discovered (millions)	1,830	1,861	1,231
Average per well (thousands)	3,065	3,440	2,549
Exploratory results			
Exploratory wells drilled (excluding gas wells) incl. all dry holes	10,805	10,399	7,632
New oil discovered (millions)	1,830	1,861	1,231
Average per well (thousands)	169	179	161

*Revisions in estimates credited to discovery years. Allocation of extensions and revisions shown in Table 9.
(P)–Preliminary.

TABLE 6. Results of exploratory effort. (Revised 1946).

Year	Exploratory wells and dry holes drilled	Reserves discovered			Wells per mill bbl discovered	Reserves discovered per exploratory well (thousand bbl)
		New fields (millions)	Extensions and revisions §	Total (millions)		
1935	5,231	950	1,100	2,050	2.55	392
1936	5,671	850	2,920	3,770	1.50	665
1937	6,900	929	2,046	2,975	2.32	431
1938	6,453	810	2,060	2,870	2.25	445
1939	6,732	341	1,870	2,211	3.02	328
1940	7,032	286	1,330	1,616	4.38	230
1941	7,388	430	1,095	1,525	4.83	207
1942	6,123	260	950	1,210	5.05	198
1943	6,703	282	960	1,242	5.40	185
1944	7,757	511	1,170	1,681	4.62	216
1945	10,399	420	1,610	2,030	5.12	196
1946(P)	10,805	326	1,504*	1,830	5.90	169

*Subject to subsequent upward revisions in first estimates.
§Revisions allocated to years for which original estimates were revised. Extensions not allocated to original discovery wells.
(P)–Preliminary.

was found for each exploratory well drilled. It should be noted, however, that 1946 results make no provision for possible upward revisions in first estimates. Revisions are allocated to the years in which original estimates were revised. Otherwise, the results reflect the quantity of oil discovered by exploratory drilling in new fields and extensions of previously discovered fields for each of the years shown in Table 6. Another study of reserve discoveries related to drilling is shown in Table 8. This presents data for five-year periods beginning with 1916 and ending with 1946. During the last five years the average reserves discovered per well for all wells drilled in the United States was 38,854 bbl, whereas in the preceding five years the average was 82,388 bbl. The relationship of reserve discoveries to dry holes drilled emphasizes the need for revision in existing spacing regulations. In the last five years the average quantity of new oil found per dry hole was 121,438. This compares with an average in the preceding five years of 369,774 bbl per dry hole.

The effect of allocating extensions and revisions to years of original discovery is shown in Table 9. It will be noted that between 1935 and 1946 the industry discovered through extensions and revisions a total of 19,221,000,000 bbl of oil. More than 6,000,000,000 bbl of the oil credited to this period, however, resulted from discoveries made prior to 1935. Likewise, in 1946 discoveries by extensions and revisions were 1,729,000,000 bbl, but this quantity was allocated to previously discovered fields extending back to the year 1938. On this basis the total quantities of oil found by exploration between 1935 and 1946 have shown a marked decline from earlier years. Through the allocation of extensions and revisions adjusted oil discoveries in 1938 are shown to have been 2,920,000,000 bbl. Even after providing for probable subsequent upward revisions in discoveries during 1946, it is apparent that the net discovery credit to this year was only 576,000,000 bbl.

There are two methods by which to measure the results of the oil industry's exploratory efforts. The first method, shown in Table 9, begins with a reported inventory of 12,177,000,000 bbl and credits this entire period with the discovery of 25,616,000,000 bbl. By subtracting the oil produced during this period amounting to 16,616,000,000 bbl, the proved reserve inventory as of January 1, 1947, is placed at 21,177,000,000 bbl. By the second method, which is used by the writer, namely, to allocate back to the original discovery years all oil

TABLE 7. Wildcat wells—oil discoveries.

Year	Total wildcat wells drilled	Wildcat oil producers	Per cent oil producers	New reserves discovered (net) †	Average reserves discovered, all wildcats	Average reserves discovered per wildcat producer
1935	1,675@	190@	13.4	2,325	1,388	12,237
1936	1,950@	215@	10.3	2,305	1,182	10,721
1937	2,224	250@	12.4	2,629	1,182	10,516
1938	2,638	260@	9.9	2,920	1,107	11,231
1939	2,589	245@	9.5	1,916	740	7,820
1940	3,038	300	9.9	1,596	525	5,320
1941	3,264	504	15.4	1,375	421	2,728
1942	3,045	408	13.4	925	304	2,267
1943	3,319	432	13.0	872	263	2,019
1944	3,848	493	12.8	974	253	1,976
1945	4,105	541	13.2	875	208	1,580
1946(P)	4,303	597	13.9	576*	134	965

†Extensions and revisions allocated to original discovery wells.
*Provides for subsequent upward revision of about 250 million barrels.
@Estimated. (P)–Preliminary.

TABLE 8. Reserve discoveries related to all drilling. (All figures on an annual average basis).

Period	All wells drilled	Oil wells completed	Reserves found (millions)	Average reserves discovered per well (bbl)		
				All wells	Oil wells	Dry wells
1916–20	27,359	19,732	660	24,124	33,448	118,471
1921–25	23,715	15,872	920	38,794	57,964	163,381
1926–30	24,678	14,634	2,870	116,298	196,118	388,889
1931–35	15,880	10,595	1,385	87,217	130,722	350,367
1936–40	27,589	19,107	2,273	82,388	118,962	369,774
1941–46	23,910	13,706	929	38,854	67,431	121,438

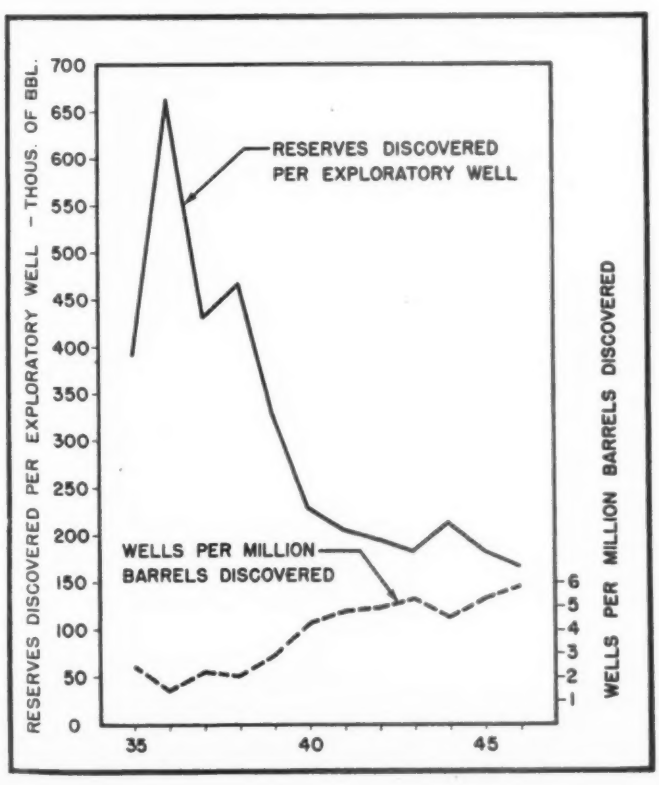
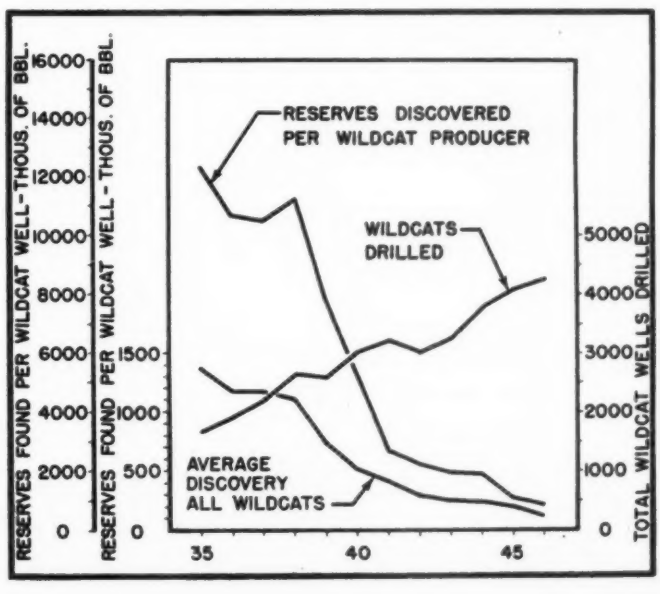


FIG. 7. Left, greater exploratory effort—less favorable results. (See Table 6)

FIG. 8. Below, more wildcat wells—less oil found. (See Table 6)



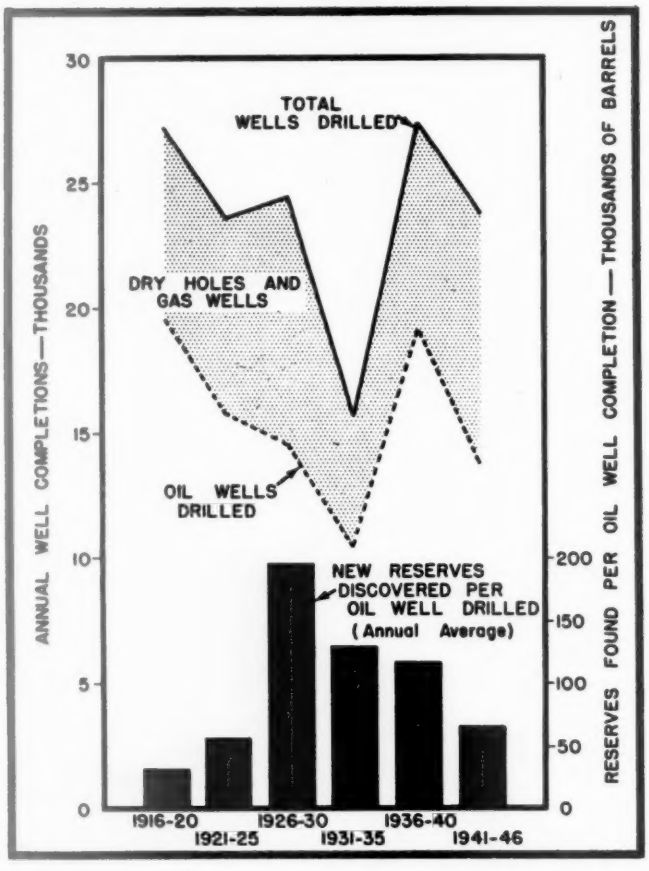
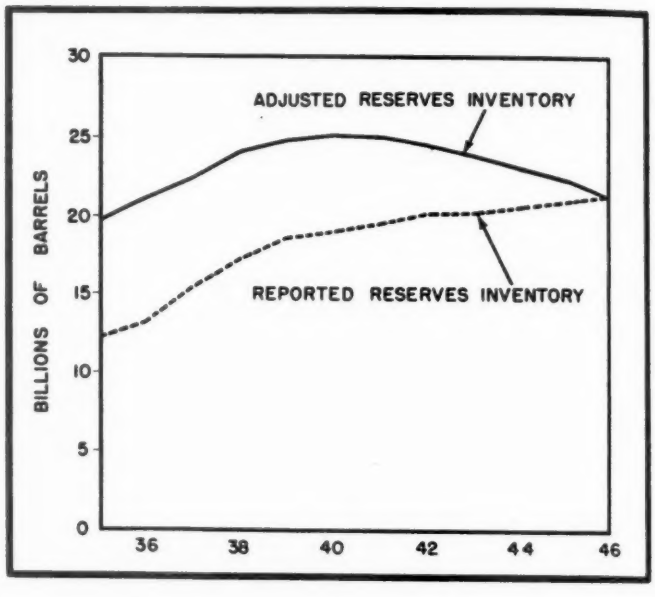


FIG. 9. Left, effect of war upon average annual discoveries per well. (See Table 8)

FIG. 10. Below, effect of allocations to original discovery years upon reserve inventory. Peak established in 1940. (See Table 9)



found through extensions and revisions, the opening inventory becomes 18,525,000,000 bbl, whereas the net discoveries credited to the period are reduced to 19,268,000,000 bbl. After accounting for the quantity of oil produced during this period, the final results are the same as indicated by Method 1, namely reserves on January 1, 1947, of 21,177,000,000 bbl.

The facts disclosed herein emphasize the need for increased rate of discovery of petroleum reserves to meet future oil requirements. One thing that seriously retarded discoveries during the war period was federal control of crude oil prices at sub-normal levels. Other factors were a serious shortage of experienced manpower and the lack of adequate supplies of critical materials. Recent price increases have provided some incentive for the wildcatter to search for new sources of oil supply. In the light of high finding and replacement costs of the last several years, however, it is apparent that an even greater price incentive is necessary to encourage a more intensive search for new reserves. During the war years the Petroleum Administrator for War urged the oil industry to drill at least 5000 wildcat wells annually. Actually, the industry did not succeed in reaching that level, and even in 1946 the total number of wildcats drilled amounted to only 4303.

The high cost of finding oil can be substantially reduced if a sufficient number of wildcat wells are drilled and if the resulting quantities of oil discovered are substantially greater than has been the experience over the last six years. Obviously, even though expenditures are excessive in relationship with past experience, the discovery of greater quantities of oil by both wildcat and extension operations would contribute to a material reduction in unit costs. The fact remains that we have not found sufficient quantities of new reserves during the last six years and we must find more oil in the future if we are to maintain an adequate backlog of reserves in relationship with prospective production requirements.

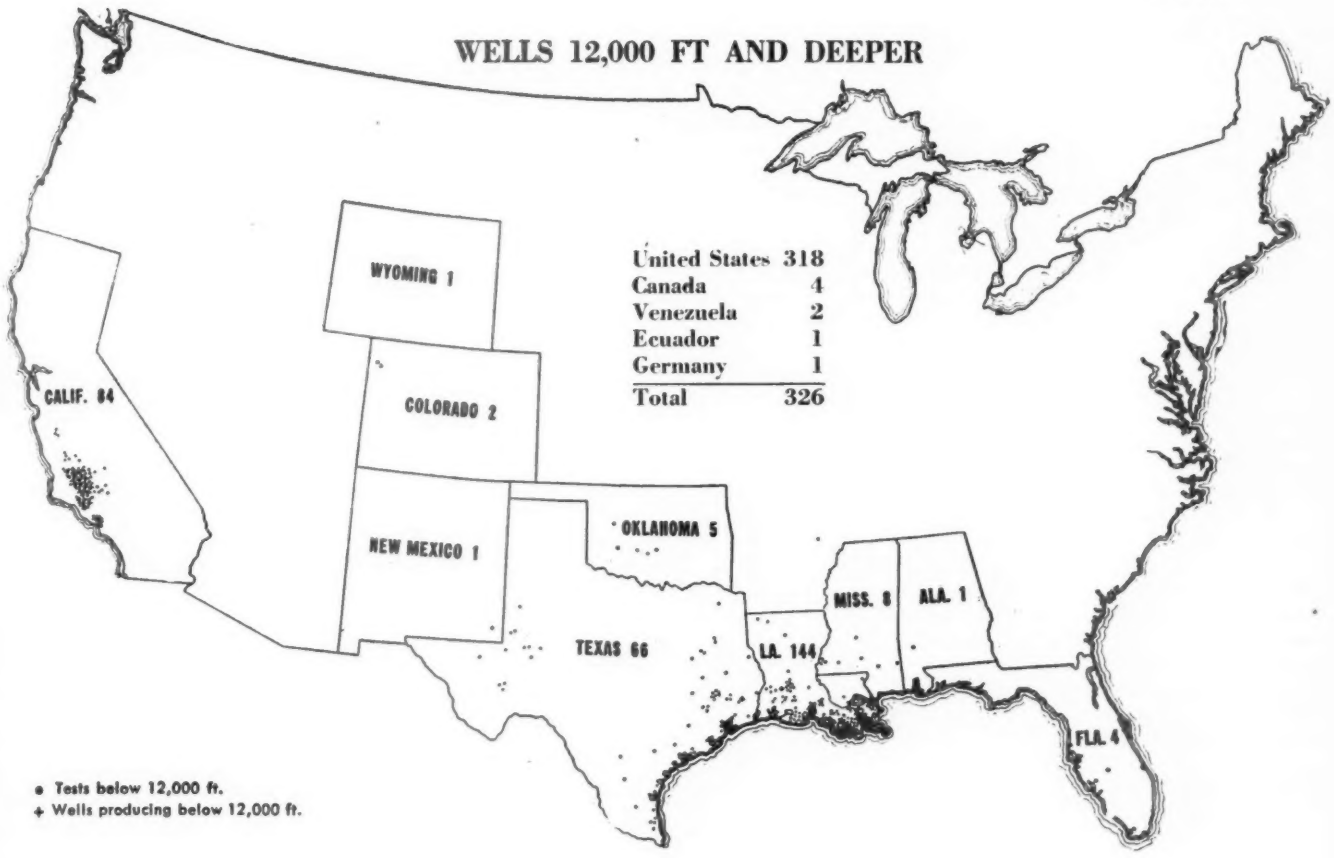
When ample steel is available and crude prices advance to a level that will justify a thoroughgoing exploration and wildcatting program, there should be no apprehension over the ability of the oil industry to meet the nation's future requirements for oil. ★★★

TABLE 9. U. S. petroleum reserves situation. (Revised 1946).

Year	Reported reserve inventory January 1 (a)	New field discoveries (a)	Extensions and revisions (a)	Total oil found† (a)	Production	Allocation of extensions and revisions	Plus new field discoveries (a)	Adjusted oil discoveries‡	Adjusted reserve inventory January 1
1935	12,177	950	270	1,220	997	1,375	950	2,325	18,525
1936	12,400	850	913	1,763	1,100	1,455	850	2,305	19,853
1937	13,063	929	2,793	3,722	1,278	1,700	929	2,629	21,058
1938	15,507	810	2,244	3,054	1,213	2,110	810	2,920	22,409
1939	17,348	341	2,058	2,399	1,264	1,575	341	1,916	24,116
1940	18,483	286	1,607	1,893	1,352	1,310	286	1,596	24,768
1941	19,024	430	1,539	1,969	1,404	945	430	1,375	25,012
1942	19,589	260	1,619	1,879	1,385	665	260	925	24,983
1943	20,083	282	1,203	1,485	1,503	590	282	872	24,523
1944	20,065	511	1,556	2,067	1,678	463	511	974	23,892
1945	20,454	420	1,690	2,110	1,711*	435	420	855	23,188
1946(P)	20,853	326	1,729	2,055	1,731*	250§	326	576§	22,332
1947(P)	21,177								21,177
Total 1935-36	..	6,395	19,221	25,616	16,616	12,873	6,395	19,268	..

	Method 1 (†)	Method 2 (‡)
Reserves inventory January 1, 1935	12,177,000,000	18,525,000,000
Discoveries	25,616,000,000	19,268,000,000
Total	37,793,000,000	37,793,000,000
Production	16,616,000,000	16,616,000,000
Reserves inventory January 1, 1947	21,177,000,000	21,177,000,000

†Crediting discoveries and revisions currently.
‡Crediting extensions and revisions to years of original discovery.
*Does not account for all condensate production—production reported by U. S. Bureau of Mines.
§Provision for subsequent revisions in first estimates.
(a) Reported by A.P.I. Committee on reserves—1946 estimated by author.
(P)–Preliminary.



Deep exploratory wells on increase

ERNESTINE ADAMS, *Associate Editor*

ONE HUNDRED AND SIX new wells were drilled to depths below 12,000 ft in 1946 to bring the total of deep wells in this class to 326. The number for 1946 was 66 per cent more than those drilled in 1945, striking evidence of the trend in the search for petroleum.

EXCLUSIVE

Although the depth record was broken in 1946, the break was slight and the temporary record holder, Pacific Western Oil Corporation No. 1 National Royalties, Miramonte field, Kern County, California, has run into trouble and is still fishing at this time. In the meantime Superior Oil Company of California No. 1 Weller, Caddo County, Oklahoma, became the deepest well in the world in February, 1947.

The new drilling depth, however, amounted to only 13 ft more penetration. Last year Phillips No. 3 Fanny Schoeps, Brazos County, Texas, held the record with 16,655 ft and the 1946 record of Pacific Western's test was 16,668 ft. Pacific Western's well made a number of new records besides being the deepest for 1946. The 8⅜-in. hole was the largest diameter ever drilled below 13,000 ft and a core from 16,538-44 ft was the deepest core ever taken. The well was drilled speedily and without a fishing job until it hit the record depth and got a record fish.

Much more important was the new record for deep production. The present deepest production, discovered in 1946, is Shell Oil Company No. 2 Smith-State Unit 1 in the Weeks Island field, Iberia Parish, Louisiana. The well was drilled to 14,301 ft and is producing from 13,778 ft. Initial production was 454 bbl of 33° gravity oil and 587,000 cu ft of gas a day with a gas-oil ratio of 1294 cu ft to 1 bbl.

Last year's record depth production was Shell No. 1 Smith-State in the same field but the new production record is 258 ft deeper. Last year's record depth and record production were 3135 ft apart; this year they are only 2890 ft apart. It has been interesting through the years how faithfully production has followed the deep drill. In 1935 when the first well went below the 12,000-ft mark to 12,786 ft, the deepest production was from 9836 ft, a difference of 2950 ft, which is a little more than it is now.

TABLE 1. Deep wells by years.

Years	No. deep wells	Years	No. deep wells
1935	1	1942	17
1937	5	1943	17
1938	15	1944	37
1939	24	1945	69
1940	17	1946	106
1941	18	Total	326

Wells 12,000 ft and deeper according to years are given in Table 1. The plan of going down below that level caught on in 1938 and remained fairly steady during the war years but began to spread more rapidly with the advent of peace and the accompanying lift of controls on machinery and operations. The increase in deep well drilling shows acceleration in the last two years. The 66 per cent increase for 1946 over 1945 is greater than the 54 per cent of 1945 over 1944.

The same spirit of adventure that seized the early pioneers of the American oil industry and sent men over the face of the United States in their search for the black gold is still evident in the pioneering of new depths. Operators, big and little, are just as eager to drill to greater depths to find new deep sands as the old timers were to drill a new wildcat from the surface.

Last year 39 companies were listed

that had drilled wells 12,000 ft and below in the 10 years that that depth had been penetrated. This year shows many more operators joining the deep drilling fraternity with a total of 61 different companies that have sent the drill down past 12,000 ft to see what they could find. A list of these companies and the number of deep wells they have is in Table 2.

To a large extent deep drilling carries the suppressed excitement of any wildcatting. Most of these deep wells are wildcats, at least with respect to the deepest formations, even though they go through developed producing strata in upper levels. This factor is in some ways a mitigating circumstance. If production is not found in the lowest depths there is often production in other formations that can be recovered from the well. Of the 326 deep wells 116 have found production at some level, 99 of these below 10,000 ft. Many have had encouragement from shows of oil and gas in deeper formations. These could not be called commercial production with present practices but with new and improved production there would be a change in the situation.

The intensive search for deep production is extending over more territory as well as increasing in number of tests. One of the interesting wells is the record holder for the state of Mississippi, Superior of California No. 1 Cassie Bradford, Forrest County. Completed at 15,730 ft, the well is said to be testing at several points.

Deep drilling around the Gulf of Mexico is not confined to the coast line. Miles out in the open water tests are making depth records for over-water drilling. It is more than probable that there will be additions to the list of wells greater than 12,000-ft deep from wildcats and other wells to be drilled in the Gulf during 1947. Geologists believe that the vast petroleum deposits of the Gulf tidelands lie at great depths under the sea bed.

One state far north of the Gulf, Wyoming, had its first deep test in 1946. Mountain Fuel Supply Company of Rock Springs Unit 1 drilled to 12,895 ft in the Church Buttes field of Unita County. The elevation is 6947 ft.

More countries outside the United States are feeling the dip of the drill. Venezuela has two new deep wells, one the deepest in the world outside the United States. Caribbean Petroleum Company No. 2-A Curacao in Zulia, West Venezuela, penetrated to 15,106 ft last year and operations have been suspended. Ecuador has a new depth record of 13,206 ft at the International Ecuadorian Oil Company No. 1 Bajada, in southwestern Ecuador.

France was reported to have a 14,000-ft test but reliable information discounts this. The two deepest wells are the Aurignac, which is 10,155 ft, and the Puymarin, which is drilling below 10,000 ft and may reach 12,000 ft. Both wells are owned by the Regie Autonome des Petroles, a government company.

Another report indicates that Russia had a test below 12,000 ft in the vicinity of Baku but there has been no verification from the Petroleum Division of Commissariat for Fuels.

In the rich fields of the Middle East there are as yet no 12,000-ft holes but there are some much deeper than generally supposed. Arabian American Oil Company has a well in Saudi Arabia on the El Jauf structure with a total depth of 10,974 ft. The deepest producing well in the area is on the Abu Hadriya structure at a depth of 10,220 ft.

Two new deep wells have been drilled in Canada but the record well for that

TABLE 2. Deep well operators.

Company	Drilling	Producers	Dry wells	Total
Abercrombie Company, J. S.		2		2
Alliance Petroleum Corporation		1		1
Amerada Petroleum Corporation		1	2	3
American Republics Corporation			1	1
Argo Oil Corporation		1		1
Arkansas Fuel Oil Company			1	1
Atlantic Refining Company		3	4	7
Barnsdall Oil Company		1	1	2
Belridge Oil Company	1			1
Benedum Interests, M. L.		1		1
British-American Oil Producing Company		1		1
Burton-Sutton Oil Company, Inc.			1	1
California Company		1	4	5
California Exploration Company			1 (show)	1
Caribbean Petroleum Company	2			2
Chanslor-Canfield Midway Oil Company		1	1	2
Cities Service Oil Company		1	1	2
Continental Oil Company		12	17	29
Fohs Oil Company		2	1	3
Four Star Oil Company	1			1
General Petroleum Corporation		1	4	5
Gravis & Mitchell		1		1
Gulf Oil Corporation	2	4	18	24
Honolulu Oil Corporation		1		1
Humble Oil and Refining Company		9	24	33
Hunt Oil Company			1	1
Imperial Oil Company, Ltd.			2	2
International Ecuadorean Petroleum Company			1	1
Kings County Oil Company	1			1
Livermore Company, George P.			1	1
Lloyd Corporation	1			1
Louisiana Land and Exploration Company			2	2
A. N. Macrates & Sons			1	1
Magnolia Petroleum Company		8	2†	10
Mountain Fuel Supply Company		1		1
Noranda Oil Company		1		1
Oklahoma Natural Gas Company			1	1
Pacific Western Oil Corporation	1 (fish)		2	3
Pan American Production Company	1	2		3
Phillips Petroleum Company		2	18	20
Plymouth Oil Company			1	1
Pure Oil Company		1	2	3
Quintana Petroleum Corporation			1	1
Richfield Oil Corporation	1		1	2
Seaboard Oil Company			1	1
Shell Oil Company	3 (testing)	7	7	17
Sinclair Oil Corporation		1	1	2
Socony-Vacuum Oil Company			1	1
Standard Oil Company of California		10	9	19
Standard Oil Company of Ohio		1	1	2
Stanolind Oil and Gas Company		5	6	11
G. W. Strake Oil Company		1		1
Sun Oil Company		2	2	4
Superior Oil Company of California	4	7	6	17
Taylor Oil Company	1			1
The Texas Company	3	11	17	31
Tide Water Associated Oil Company		2 (shows)	7	9
Union Oil Company of California		7	4	11
Union Producing Company		5	1	6
Western Gulf Oil Company	1	3	1	5
German well			1	1
Totals	23	116	187	326

†One an injection well

TABLE 3. Deep wells by location.

Alabama	
Clarke	1
California	
Fresno	3
Imperial	1
Kern	56
Kings	4
Los Angeles	7
Orange	2
Tulare	2
Ventura	9
	84
Canada	
Alberta	3
New Brunswick	1
	4
Colorado	
Rio Blanco	2
Florida	
Charlotte	1
Collier	1
Highlands	1
Monroe	3
	6
Louisiana	
Acadia	3
Allen	1
Ascension	1
Assumption	3
Beauregard	4
Bossier	1
Calcasieu	2
Cameron	6
Claiborne	1
Evangeline	10
Iberia	12
Jackson	1
Jefferson Davis	4
Jefferson	8
La Fourche	11
Plaquemines	11
Rapides	1
St. Bernard	1
St. Charles	3
St. John the Baptist	1
St. Landry	1
St. Martin	5
St. Mary	17
Terrebonne	22
Vermilion	13
Washington	1
	144
Mississippi	
Adams	3
Forrest	1
Green	1
Jeff Davis	1
Lincoln	1
Rankin	1
	8
New Mexico	
Lea	1
Oklahoma	
Caddo	1
Dewey	1
Grady	1
McClain	1
Washita	1
	5
Texas	
Anderson	2
Andrews	2
Brazoria	11
Brazos	1
Brooks	1
Cameron	1
Chambers	1
Colorado	1
Crane and Upton	1
Duval	1
Ector	2
Freestone	1
Gaines	1
Galveston	1
Goliad	1
Hardin	2
Harris	3
Jackson	1
Jefferson	1
Kenedy	
Liberty	3
Madison	1
Matagorda	2
McMullen	1
Midland	1
Montgomery	7
Newton	1
Nueces	1
Pecos	3
Reeves	1
Shelby	1
Smith	2
Titus	1
Trinity	1
Willacy	3
Winkler	1
	66
Wyoming	
Uinta	1
Ecuador	
Southeast area	1
Germany	
Venezuela	
Zulia	2

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,000 0.40	3- 9-45 12-21-44	Humble 2 I. R. Price	Delta Farms, La Fourche, La.	Miocene (shale) Miocene	16"-166', 10¾"-2533', 5½"-10,407'	522 B 36.3° 310 MCF 11/64"	‡1660, °4371, *9400, 561	60 perf. at 9415-29'
12,000 221	5-12-45 11-25-44	Stanolind 1 H. M. McMahon	J. Dorsey Sur. A-169, Montgomery, Texas	"G" Wilcox "G." Wilcox	20"-89', 13⅜"-2959', 7"-11,720'	171 B 11 MMCF ¼"	‡3200	Wildcat. Perf. at 11,500-622'
12,000	9-24-45 8- 1-45	Union of Calif. 540-4 A State	W. White Lake, Vermilion, La.		16"-167', 10¾"-2756'	Dry		39 bits used
12,000	5- 5-45 12-13-44	Stanolind 1 J. Sabatier	41-12s-5e, Iberia Parish, La.	Salt	16"-120', 10¾"-2478', 7"-9206'	Dry		Wildcat
12,000	Drilling	Texas 2 Bender Estate	T. W. Marshall Sur. Harris County, Texas					Wildcat
12,001 18	1- 6-42 11- 3-41	Gulf 1 Joseph Eschete	Lapeyrouse, Terrebone, La.	Miocene	20"-120', 13⅜"-2515'	Dry		Wildcat
12,001 12.5		Phillips 1 Livingston	Willacy, Texas	Frio 8745' to TD		Dry		Wildcat
12,001	12-31-43 8-22-43	Union of Calif. 540-1 A State	W. White Lake, Vermilion, La.	Miocene Miocene	16"-181', 10¾"-2670', 5½"-10,768'	Shut in gas well		32 perf. at 10,660-75'. 56 bits used
12,003 0	8-29-44 6- 4-44	Humble 1 State Land	30-16s-Sw, Cameron, La.	Miocene	20"-102', 13⅜"-2495', 9⅝"-9225'	Dry-		Wildcat
12,005 44.61	11-12-42 6-22-42	Phillips 1 Bernadine	Chocolate Bayou, Brazoria, Texas	Frio	20", 13⅜", 9⅝", 5½"	Dry		
12,005 390.0	6-16-44 10-17-43	Phillips 1 Denkman	13-7n-4e, Rankin, Miss.	Cotton Valley	10¾" surface	Dry		Wildcat
12,006 136.6	6-19-46 1-31-46	Humble B-1 Gaylord Container	42-1s-14e, Washington, La.	Lower Cret.	20"-121', 13⅜"-2644' 9⅝"-6383'	Dry		Wildcat
12,007 1.0	2-26-46 10-31-45	Humble 1 La. Delta Farms	19-17s-23e, La Fourche, La.	Miocene	20"-207', 13⅜"-2492', 5½"-10,735'	69 B 30.8° 40.5 MCF 3/16"	‡610, 582	Wildcat. 32 perf . at 10,622-26'
12,010 82.1	7-20-46 10-28-45	Union Prod. 1 Belgard	NE SW 14-4n-3e, Rapides, La.	Glen Rose Tuscaloosa	16"-78', 10¾"-2219', 7"-10,021', 2⅛"-9713'	361 B 46° 550 MCF 3/16"	°1500, ‡1800, 1524	Wildcat. 120 perf. at 9680-738'. 108 bits used
12,010 389	2- 7-45 5-25-44	Humble 1 C. C. Searcy	H. Gilbert Sur., Titus, Texas	Smackover	13⅜"-643', 9⅝"-4539'	Dry		Wildcat
12,010	5- 8-45 9- 5-44	Pan American 1 G. B. Crane	Willamar, Willacy County, Texas	Frio	10¾"-1534', 7"-9012', 5" liner 10,709'	70 B 30.8°		Perf. at 7060-90'
12,010	12-31-44 3-18-44	Humble 1 Ada W. Stowers	Adams County, Miss.	Lower Cret.	20"-90', 13⅜"-3012'	Dry		Wildcat
12,010	11-16-44 9- 7-44	La. Ld. and Ex. Co. 1 Fee	8-20s-13e, Terrebone, La.		16"-150', 10¾"-2484'	Dry		Wildcat
12,010	6-11-44 3-19-44	Texas 1 J. G. Timolat	Delta Duck Club, Plaquemines, La.	Hard shale	18", 10¾", 7"	Dry		
12,011 172-160	9- 1-43 2- 7-43	Magnolia 1 A H & B D Anderson	GH&H RR Sec. 15, Colorado, Texas	Wilcox Vegua and Wilcox	16"-386', 10¾"-3953', 7"-9659'	88 B 51° 17 MMCF ¼" and 5/16" 44 B 55.3° 35 MMCF ¼"	°2370, ‡2310, 80,500 and 131,000	Discovery well Chesterville. Perf. 9500-40' and 6850-60'. Dual producer
12,012	6-23-42 3-24-42	Sun Oil	Belle Isle field, St. Mary, La.	Miocene	13⅜"-2797'	Dry		
12,012	3-21-46 1-24-46	Union of Calif. 1 N. Breaux Lbr.	Grassy Lake, Assumption, La.	Miocene		Dry		
12,013	6-17-39 3-17-39	Gulf 1 Grandison	Grandview Bay, La Fourche, La.	Miocene	20"-90', 13⅜"-2160' 9⅝"-8214'	Dry		Wildcat. 52 bits used
12,015	12-26-41 10-26-41	Texas 3 State Bayou Perot	Delta Farms, Jefferson, La.	Shale	10¾"	Dry		Wildcat
12,018	2- 5-43 9-29-42	Shell 66-22 Henderson	Nicholson, Fresno, Calif.	Cretaceous	13⅜"-929', 9⅝"-9025'	Dry		Wildcat
12,019	5- 1-40 9-28-38	Gulf 4 State "RR"	Lake Borgne, St. Bernard, La.	Oligocene	20"-118', 13⅜"-1696' 10"-8162', 7"-10,494'	Dry		Wildcat
12,019	6-14-46 9-11-45	General Pet. 84 Government	SE SE NE 15-2s-96w, Rio Blanco, Colo.	Mesa Verde	16"-209', 10¾"-3201'	Shut in		Wildcat
12,020	5- 4-44 3-19-44	Phillips-Sohio 1 Amelia	13-16s-13e, Assumption, La.	Miocene	16", 10¾"	Dry		Wildcat
12,020	2-26-45 9-11-44	G. W. Strake 1-w, P. G. Krohn "B"	Conroe, Montgomery, Texas	Wilcox Conroe	13⅜"-1294', 9⅝"-6591'	403.20 B 38.5° ¼"	°825, ‡425, 374	Wildcat. 40 perf. at 5101-15'. 52 bits used.
12,020 7.38	4-19-43 1-28-43	Arkansas Fuel 1 Shadyside	5-15s-10e, St. Mary Parish, La.	Lower miocene	16"197', 10¾"-2519'	Dry		Wildcat
12,021 3	1-31-44 12-20-43	Gulf 1 South Shote O & D Co.	Presque Isle, Terrebonne, La.	Miocene	20"-93', 13⅜"-2091', 9⅝"-8185'	Dry		Wildcat
12,022	1-29-45 8-31-44	Superior 5-C T. A. McWhorter	Montgomery, Texas		20"-100', 13⅜"-1523' 7"-11,880'	194 B 55.5° 3414 MCF		93 perf. at 11,410-27'
12,022	6- 1-44 3- 5-44	Texas 93 La. Ld. & Ex.	Leeville, La Fourche, La.	Broken sand	16", 10¾", 7"	279 B 32.6° ½"		Perf. at 11,408.28'
12,023	1-20-42 11-14-41	Continental 4 Tate Unit 27	Ville Platte, Evangeline, La.	Wilcox	10¾"-2019' 6"-11,160'	52 B 39° 324 MCF ½"	§1400, ^500, *1764, 620	71 perf. at 8992-9010'

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, *datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,027	5-20-40 9- 4-39	Shell 45-9, BVA	Buena Vista Hills, Kern, Calif.	Miocene	13⅜"-1500', 9⅝"-7990'	Dry		Wildcat
12,030	12- 7-39 8-28-39	Texas 3 State Horseshoe	Horseshoe Bayou, St. Mary, La.	Shale and lime	18⅝", 13⅜"	Dry		
12,030 70	10- 4-46 5-12-46	Magnolia 1 Levi Smith Est.	Mamou, Evangeline, La.	Wilcox	16"-177', 10¾"-4496' 7"-12,024	232 B 48.4° ⅛"	‡3900	116 perf. at 11,525-45'
12,033 27.35	9-24-41 6- 6-41	Phillips 1 Fitzsimmons	Erath, Vermilion, La.	Miocene	16"-113', 10¾"-2544' 5½"-11,942'	289 B 60.6° 1164 MCF 13/64"	‡3290, *2815, +10,200, 4027	Wildcat. 10 perf. at 10,147-50'
12,033	5-28-45 4- 2-45	Texas 533-1 State	Little Lake, Jefferson, La.	Sandy shale	16"-, 10¾"	Dry		Wildcat
12,034	12-11-46 5-13-46	Stanolind 8 South Jennings	15-10s-3w, Jeff Davis, La.		7"-10,625'	45 B 47.5° 5/64"	‡6800, ^7000, 16,910	Wildcat. 12 perf. at 10,594-98'
12,035 45.10	1- 3-45 6-28-44	Phillips 1 Banfield	Chocolate Bayou, Brazoria, Texas	Miocene	20"-103', 9⅝"-7021', 5½"-11,562'	245 B 46.2° 250 MMCF ¼"	^6500, *6691, +10,950, 23,216	20 perf. at 11,012-20'
12,035	2- 7-42 7-24-41	Macrates Sons 1 Haberfelde	S. Greeley, Kern, Calif.		13⅜"-142'	Dry		Failed to recover from fishing job
12,037 70	8- 7-46 5-14-46	Magnolia 1-H Deshotels	Mamou, Evangeline, La.		16"-194', 10¾"-4488', 7"-12,037	227 B 47.6° ⅛"	‡3775, 2788	71 perf. at 11,762-72'
12,038	12-13-44 9- 9-44	Texas A-1 White & Friant	Sorrento, Ascension, La.	Shale	16", 10¾"	Dry		
12,041 1.0	11- 3-44 8-27-44	Humble F-1 Miami Corp.	Black Crook Bayou, St. Marys, La.	Miocene	20"-117', 13⅜"-2732'	Dry		Wildcat
12,042	11-15-43 8- 1-43	W. T. Burton 1 Erwin Est.	Calcasieu, La.	Lower miocene	10¾"-1950', 7"-10,790'	Dry		Wildcat
12,045	4- 8-46 12-19-45	Continental 1 White Castle Lbr.	28-12s-13e, Assumption, La.	Marginulina	20"-95', 13⅜"-1631', 9⅝"-7965'	Dry		Wildcat
12,050 75	8- 6-46 5-12-46	Magnolia 1 W. Reed	Mamou, Evangeline, La.	Wilcox Morbin sand	16"-223', 10¾"-4513', 7"-12,050'	86 B in 9 hr 52° ⅛"	‡3800, 2340	168 perf. at 11,549-69'
12,052 23	5- 1-46 2- 1-45	M. L. Benedum 1 O. D. Robinson	NW 29-59s-40e, Monroe, Fla.	Lower cret.		Dry		Sunnyland lime of Collier Co., Fla., at 10,147 or 10,170'
12,056	5-10-40 3- 1-40	Texas 4 State	Horseshoe Bayou, St. Mary, La.	Hard shale and lime	18⅝, 11¾"	Dry		
12,056	1-18-44 7-31-42	Shell 1 Norman	Jumping Pound, Canada	Madison	13⅜"-607', 7"-9257'	Dry		Wildcat
12,057	1- 4-43 8-19-42	Humble 1 La. Furs	Pecan Is., Vermilion, La.	Miocene Robulusi sand	20"-172', 13⅜"-2535', 7"-11,418'	10 B 50.8° 730.08 MCF ⅛"	‡4090, *5090 +10,875 73,080	,96 perf. at 11,240-60', 20 at 10,847-53', 190 at 10,852-3'
12,058	4-16-42 1-27-42	Texas 6 St. Mary Parish Ld.	Horseshoe Bayou, St. Mary, La.	Miocene	11¾"-1925', 7"-11,124', 5½"-12,048'	70.33 B 51° 5/64"	‡3790	240 perf. at 11,245-320'
12,060	12- 9-45 11- 9-44	Texas 77 State	Caillon Is., Terrebonne, La.	Shale	10¾", 7", 5"	354 B ⅛"	‡1900	Wildcat. 192 perf. at 11,652-700'
12,063 37	5-23-41 12-29-40	Gulf 1 Petit Anse Co.	Avery Is., Iberia, La.	Miocene	20"-90', 13⅜"-1831', 5½"-5815'	Dry		Wildcat
12,075 79	8-16-46 5-10-46	Magnolia 1 Morein Landry	Mamou, Evangeline, La.	Wilcox	16"-200', 10¾"-4508', 7"-12,073'	265 B 48.2° ⅛"	‡2000, 2479	70 perf. at 11,774-84'
12,080	12-25-39 9-30-39	Continental La Terre Co., Inc.	Jug Lake, Terrebonne, La.	Cyclammina (Mio)	20"-60', 18⅝"-238', 13⅜"-1970'	Dry		Wildcat
12,082	2-21-44 11-23-43	Continental 4 Pardee Co.	Reddell, Evangeline, La.	Wilcox	10¾"-2026'	Dry		
12,088 63	3- 6-45 10-13-44	General Pet. 2 Heath	Buena Park, Orange, Calif.	Miocene	13"-600' 10¾"-1307'	Dry		Wildcat
12,088	10- 9-38 5- 9-38	Continental 1 Joe Sturdivant	Lake Arthur, Jefferson Davis, La.	Marginulina Sturdivant	13⅜"-1954', 8⅝"-9811', 6⅝"-2917'	307 B cond. 52.5° 3311 MCF 3/16"	§1100, ^5400, 10,780	Wildcat. 30 perf. at 9865-80' Recompleted 9-25-46 from 10,830-62' IP 81 B 48°, 1847 MCF
12,096	3-14-46 6-11-44	Phillips 1 Elsinore	Pecos, Texas			Dry		
12,100 29	9-26-46 6-25-46	Atlantic 1 Grand Lake	19-13s-10e, St. Mary, La.		24"-70', 16"-229', 10¾"-2525'	Dry		Wildcat. 58 bits used
12,105 1	5-24-46 4- 4-46	Humble 4-H Miami Corp.	Bayou Carlin St. Mary, La.	Miocene	10¾"-2734.8'	Dry		Wildcat
12,112	9-17-45 5-29-45	Shell 44 Edison	Ventura, Calif.	Lower pliocene Lower pliocene	13⅜"-700', 9⅝"-7130' 7"-10,420'	1096 B 30.5° 866 CF 13/64"	©3150, ‡3100, 790	Perf. at 10,434'-12,112'
12,115	6- 3-45 2- 8-45	Atlantic 5 Adeline Sugar Fcty.	North Jeanerette, St. Mary, La.		16"-79', 10¾"-3222' 5½" to TD	259 B 34° ⅛"	‡2450	48 perf. at 11,430-38'
12,115	11- 1-37 3-18-37	Texas 1 State Bayou Norman	La Fitte, Jefferson, La.		18⅝", 13⅜", 9⅝"	1817 B 36.8°	BHP 1600	Perf. at 9530-630'
12,116	2- 8-44 10- 4-43	Western Gulf 31-7 Symons	Paloma, Kern, Calif.	Symons (mio) Symons	13⅜"-1257', 7"-11,354'	547 B cond. 55° 331 MCF 18/64"	©1925, ‡1500	Slotted at 11,250-323'
12,125	5-15-39 10- 2-38	Texas 5 State	Lake Fausse Point, Iberia, La.	Sandy shale	22", 13⅜", 7⅝", 5½"	Dry		
12,127	8-14-45 9-24-44	Phillips 1 Powell	Pecos, Texas		16"-650', 10¾"-3280'	Dry		Wildcat

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by ©flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, *initial reservoir, +datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,128	1-29-37 10-20-36	Stanolind 1 F. Stovall	South Abbeyville, Vermilion, La.	Amphistegina (L. mio)	20"-384', 13⅜"-1984'	Dry		Wildcat
12,133	11-15-44 8-31-44	Texas 34 La. Ld. & Exp.	Paradis, St. Charles, La.	Sand	16", 10¾", 7"	163 B 37° ⅛"	‡1400	Perf. at 10,360-75'
12,138	6-26-41 1-16-41	Texas 47-15 SP	Bowerbank, Kern, Calif.		13⅜", 8⅝", 5½"	11,605 MCF		40 perf. at 4252-62'
12,139 299.76	Drilling 10-24-46	Western Gulf 16-6 LAAC	Paloma, Kern, Calif.		13⅜"-1265'			
12,141	3-21-45 1-14-45	Humble 5 Louisiana Furs	Pecan Island, Vermilion, La.	Miocene	10¾"-2652.96'	Dry		
12,144 298	2-20-40 9- 6-39	Union of Calif. 4-23 Bowerbank	Rio Bravo, Kern, Calif.	Miocene	13⅜"-1226', 8⅝"-9422', 5¾ and 6⅝"-11,622'	Gas		Completed as shallow gas well
12,149 70	1- 8-45 4-29-44	Pure 2 J. M. McDowell	Carthage Point, Adams, Miss.	Lower cretaceous Massive 45' thick	16"-125', 10¾"-1828', 7"-10,290', 5"-10,385'	91 B cond. 56° 2 MMCF ⅛"	⊖475, ‡3175	Wildcat. 70 perf. at 10,276-83'
12,149 20.5	10- 2-41 3-20-41	Gulf 1 Emile Picau	Lapeyrouse, Terrebonne, La.	Miocene Miocene 17' thick	20"-90', 13⅜"-2452', 7"-11,354'	2320 MCF 5/16"	‡3675, ^4000, 11,200	Wildcat. Opened Lapeyrouse field. 60 perf. at 10,883-94'
12,149	12- 2-39 9- 9-39	Continental 1 Berustein et al	Rigolettes, Jefferson, La.	Oligocene	18⅝"-229', 13⅜"-1985	Dry		Wildcat
12,155	12-30-44 7-29-44	Western Gulf 55-7 Symons	Paloma, Kern, Calif.	Paloma (mio) Paloma 20' thick	13⅜"-1269', 7"-12,153'	280 B 31.2° 145 MCF 13/64"	⊖900, ‡75	180 perf. 11,800-20'
12,165	5-18-37 9-19-36	Humble 1 H. J. Ellender	Liretle, Terrebonne, La.	Miocene	20"-57', 20"-260', 13⅜"-2824', 7"-12,109'	547 B 40.6° 1948 MCF ¼"	⊖51,00, +10,500, 3560	Wildcat. 9 perf. 11,610-5'
12,177 5.6	2-26-46 10- 3-45	Humble 1 A. Marceaux	Kaplan, Vermilion, La.		20"-58', 13⅜"-2580'	Dry		Wildcat
12,184	1-22-46 3-27-45	Standard of Calif. 1 Lewis Community	Leffingwell, Los Angeles, Calif.		20"-44', 13⅜"-795', 7"-10,145'	67 B 31.6° 22 MCF	898 to 5	Wildcat. Perf. 6898-6913'. Pumping from 6915'
12,188 1977	8-24-46 11- 9-45	Continental 2 Casitas	Red Mountain, Ventura, Calif.	Grey sand and brown shale	13⅜"-538'	Dry		Wildcat. 273 bits used
12,190	4- 7-42 1-30-42	Continental 1 Homes'krs Dev. Co.	Estherwood, Acadia, La.	Marginulina	18⅝"-241', 13⅜"-1978', 9⅝"-8440'	Dry		Wildcat
12,192 16	8-15-46 5- 1-46	Tide Water 2 Buras Levee Dist.	Venice, Plaquemines, La.		24"-104', 20"-223', 13⅜"-2501', 9⅝"-9369' 5½"-12,191'	260 B 35.3° ¾"	‡2300, ⊖5021, +10,200, 12,000	156 perf. at 11,775-805'
12,200	11- 7-38 4-14-38	Amerada 2 South Coast Corp.	Raceland, La Fourche, La.	Miocene	18⅝"-238', 11¾"-2666' 7"-10,524'	Dry		
12,200	11-15-39 8-25-39	Gulf 2 Grandison Co.	Grandison Bay, La Fourche, La.	Miocene	20"-90', 13⅜"-2047' 9⅝"-8191'	Dry		Wildcat. 59 bits used
12,204 38	7-23-46 3-19-46	Pan American 1 Callihan Unit	Liverpool, Brazoria, Texas	Frio Frio 5' thick	20"-126', 13⅜"-1555' 9⅝"-6977, 7"-11,616	331 B 40° 174 MCF ¼", ⅜"	‡20	Wildcat. 91 bits used. 20 perf. at 8757-62'
12,206	7- 3-46 4- 3-46	Humble 2-C Egg	Ganado, Jackson, Texas	Vicksburg	20"-57', 13⅜"-2759' 9⅝"-8018'	Dry		Wildcat
12,207	9-27-46 7-24-46	Atlantic 4 Lamoille Bank	South Jeanerette, St. Mary, La.		16"-115', 10¾"-3170'	Dry		Wildcat. 37 bits used
12,208	11-22-45 3-16-45	Atlantic 1 Bowie Lbr. Co.	La Fourche, La.	First operculoinides series	16"-162', 10¾"-4279'	Dry		Wildcat
12,208 1	6-19-46 1-10-46	Humble 1 Louisiana State	Four League Bay, Terrebonne, La.	Miocene	16", 10¾"-2538', 7"-12,018'	Dry		Wildcat
12,211	5-25-43 1-31-43	Atlantic 1 Adeline Sugar Factory	North Jeanerette, St. Mary, La.	Middle miocene	16"-127', 9⅝"-3158', 5½"-11,650'	92 B 50° 970 MCF ¾"		Discovery well North Jeanerette field
12,216	3-19-37 4-15-36	Continental 1 Ophe C. Hebert	Abbeville, Vermilion, La.	Oligocene	18⅝"-248', 13⅜"-1881', 7"-10,960, 5"-11,785'	50 B cond. 67° 2 MMCF 5/16"	⊖2450, ‡2800, ⊖3600, 40,000	Recompleted as salt water input well, 12-14-41
12,222 386.23	10-14-44 4- 6-44	Western Gulf 77-5 KCL	Stockdale, Kern, Calif.	Velder (L. mio)	13⅜"-1497'	Dry		Wildcat
12,222	7-21-44 6- 1-43	Continental A-1 E. M. Jones	Jones, Gaines, Texas	Ellenburger	13"-316', 9⅝"-4570', 7"-11,177, 5"-12,222	Dry		Wildcat
12,225	11- 2-39 9- 9-39	California 1 Adams-Rutley	Baratoria, Jefferson, La.			396 B 37.3° ¼"	‡1225	Discovery well Baratoria field. 20 perf. at 8204-14'. Recompleted 9-25-41 at 7638-43'
12,230 236	1-19-46 10-11-44	Humble 1 Pickering Lbr. Co.	Huxley, Shelby, Texas	Smackover Lower Pettit 22'	13¾"-962', 9⅝"-3374', 7"-8306', 5½"-8505'	13.8 B 10,139 MCF ½"	⊖3466, +6381, gas well	Wildcat. 220 perf. at 6606-28'
12,236 332	9-30-38 9-27-37	Pure 1 South Pacific Land Co.	Fresno, Calif.	Basal eocene	13⅜"-2000'	Dry		Wildcat
12,250 150	2-11-45 10-21-44	Shell 1 Groggan Mfg. Co.	Cleveland, Liberty, Texas	Wilcox Yegua	16"-80', 10¾"-3000', 5½"-5800'	294 B 40.3° 2080 MCF ¼"	‡1700, ⊖2503, +5600, 7770	Wildcat. 16 perf. at 5782-4'. 63 bits used.
12,251	2-28-46 3-17-46	Humble 1 Todd	Boggy Creek, Anderson, Texas	Pettit	20"-105', 13⅜"-2035', 9⅝"-5318'	Dry		Wildcat
12,253	10-28-46 12- 9-45	Geo. P. Livermore 1 Giles Ranch	CNW NW 35-8n-5w, Grady, Okla.	Wilcox	13⅜"-887', 9⅝"-5650', 7"-11,975'	Dry		146 bits used
12,257	6-13-39 12- 9-38	Texas 1 La. Ld. & Ex.	Bastian Bay, Plaquemines, La.	Miocene	20", 13⅜", 9⅝", 7"	Dry		Wildcat
12,259	4- 9-42 12- 5-41	Superior 1 So. Tex. Dev. Co.	NH Lake Cr., Montgomery, Texas		16"-55', 10¾"-1445', 7"-10,300', 2"-11,596	213 B 52° 2965 MCF 15/64"		240 perf. at 11,775-815'

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DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Compl't'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,261	8-10-37 9- 4-36	Texas 1 State	Horseshoe Bayou, St. Mary, La.	Sandy shale and lime	18⅝", 13⅜", 7⅝"	1152 B 39.7° ¼"	‡2000	Blew in 5-15-37. Burned an hour. Perf. at 11,863-73'
12,276 370.57	5-13-34	Stand. of Calif. 105 Baldwin-Cienega	Inglewood, Los Angeles, Calif.	Schist	22"-25', 16"-1180', 11¾"-2353', 7"-8495'	Dry		Abandoned 4-12-44
12,280 18.80	3-31-41 1-15-41	Phillips 1 State	48-20s-29e, Plaquemines, La.	Miocene	20"-164', 13⅜"-2558'	Dry		Wildcat
12,295	6-14-45 12-14-44	Phillips B-1 Houston	Chocolate Bayou, Brasoria, Texas	Frio	20"-125', 13⅜"-1412', 9⅝"-7036'	Dry (show)		
12,300	1- 2-41	Plymouth 1 E. G. Tilley	13-12s-10e, Iberia, La.		16"-180', 10¾"-1956', 2"-8080'	Dry		Wildcat. Abandoned 1-3-45
12,300	2-15-42 8-29-41	Stanolind 1 T. A. McWhorter	Lake Creek, Montgomery, Texas	Wilcox Wilcox	16"-90', 10¾"-1518', 7"-10,665'	305 B 54° 1660 MCF ¼"	°2950, ‡1750, 5450	192 perf. at 9734-66'
12,305	-44	Sinclair 1 Campbell	Sec. 11, Blk. 5, PSL, Texas	Ellenberger		Dry		Wildcat
12,313	8- 2-45 1- 2-45	Texas 1 Grupe Engebretson	8-16s-16e, Imperial Calif.		13⅜", 9⅝", 7"	Dry		Wildcat
12,315 0.40	10-28-45 7-17-45	Humble 1 State Lease 642	Lake Salvadore, St. Charles, La.	Miocene (shale)	20"-168', 13⅜"-2981', 9⅝"-8631'	Dry		Wildcat
12,327	7-21-44 6- 1-44	Union of Calif. 3-C La. Furs	Fresh Water Bayou, Vermilion, La.	Miocene	10¾"-2760', 7⅝"-12,327'	Flowed. Shut in	‡4100, ^4100	45 perf. at 11,540-55'. 31 bits used
12,328 200.90	12-19-43 6-21-43	Humble 1 J. A. Hurst	53-5n-8w, Green, Miss.	Lower cret.	16"-37', 10¾"-2491'	Dry		Wildcat
12,331	12-26-46 8-13-46	Gravis & Mitchell 25 Natalbany	12-9s-1e, Iberville, La.	New sand	16"-65', 10¾"-2317', 7"-10,377', 5"-11,703'	265 B 39° ⅛"	‡1900, 1426	Wildcat. 48 perf. 10,818-26'. St. Gabriel opener
12,335	9-30-39 10- 9-38	Texas 1 School Board	La Fitte, Jefferson, La.	Hard shale		Dry		
12,355 274	12-21-46 2-23-46	Shell 3 Tremont Lbr. Co.	Chatham, Jackson, La.	Sexton (Cotton Valley)		818 MCF ⅝"	°2175, ^2175	96 perf. at 9820-44'. 228 bits used.
12,356 16	11-19-44 8-28-44	Pure Oil 1 L. L. Trahan	9-12s-6e, Iberia, La.	Miocene	16"-120', 10¾"-2915', 7"-10,010'	Dry		Wildcat
12,357	3-21-46 11- 5-45	Gulf 1 St. Martin Ld. Co. "E"	Bayou Bouillion, St. Martin, La.	Hackberry (oli)	20"-121', 13⅜"-2020', 9⅝"-8195'	Dry		Wildcat. 76 bits used
12,366	1-11-47 4-22-46	Gulf 16 La Fourche Basin Levee	Lake Hermitage, Plaquemines, La.	Miocene	20"-109', 13⅜"-2497', 9⅝"-9212', 5½"-12,073	81 B 45.5° 3,171,312 CF ¼"	‡3750, 39,080	84 perf. at 12,022-32'. 115 bits used
12,375	3-20-46 12- 5-45	Continental 1 M. G. Fournet	113-10s-6e, St. Martin, La.	Hackberry	20"-94', 13⅜"-1556', 9⅝"-9520'	Dry		Wildcat. 50 bits used
12,381	8-22-45 11-23-44	Shell 1 Stakemiller-Rose	Long Beach, Los Angeles, Calif.	Miocene	13⅜"-1356', 7"-10,168'	Testing		Deep test wildcat
12,386	9-27-46 11- 3-45	Barnsdall-Sohio Carter-Burton	CNW NW 26-13n-13w, Bossier, La.	Fagle Mills Salt Tokyo sand	16"-96', 10¾"-2310', 7"-10,640'	54 B 41.0°		Wildcat. 125 perf. at 3228-65'. 201 bits used
12,389 545	Drilling 7-15-35	Standard-Bolsa Chica 73-30V	30-23s-19e, Kings, Calif.	Eocene	6⅝"-10,921'	500-1000 B 35°	§1900	New deep producing zone
12,395	5-10-44 3- 8-44	Union of Calif. 2-C La. Furs	Fresh Water Bayou, Vermilion, La.		10¾"-2731'	Dry		33 bits used
123.98	10-20-46 11- 6-45	Cities Service 1 Lawson "B"	N. Lindsay, McClain, Okla.	Arbuckle Second Bromide	16"-438', 10¾"-6270', 7"-10,753'	1233 B 47.6°	°2650	Production 10,904'
12,399	10-19-41 5-29-41	Union Prod. 1 M. M. Waite	Clarke, Ala.		16", 10¾"	Dry		
12,400	6- 5-45	Calif. Co. 10 Nat'l Gasoline Co. of La.	Cranfield, Adams, Miss.		16"-194', 10¾"-1817'	Dry		80 bits used
12,401	8-13-45 6-17-45	Magnolia 1 Richardson Orange	8-18s-26e, Plaquemines, La.		16"-300', 10¾"-2700'	Dry		Wildcat
12,410	9-10-46 5-11-46	Tide Water Assoc. 63 V. L. & W.	Ventura Av., Ventura, Calif.			506 B 31.3° 413 MCF		
12,431 16	4-21-45 11- 2-44	Tide Water Assoc. 1-C Manhattan Land & Fruit Co.	Venice, Plaquemines, La.	11,867-98'	24"-97', 20"-217', 13⅜"- 2469', 9⅝"-7928', 5½"-12,424'	249 B 36.6° ½"	‡1250, °5311, +11,900, 972	179 perf. at 10,867-98'. Production from 11,867-98'. Discovered new sand
12,448	3-31-46 12-20-45	Sohio 1 Matilda Gray	12-15s-14w, Cameron, La.	Upper Miocene	20"-120', 13⅜"-1515', 9⅝"-8793'	Dry		Wildcat
12,452	1- 3-45 10-10-44	La. Ld. & Ex. Co. 1 State	Pelican Lake, Terrebonne, La.	Shale	16"-195', 10¾"-2525'	Dry		Wildcat
12,455	3-14-43 10- 8-42	Am. Republic 1-X Luteher-Moore Lbr	3-6s-13w, Beauregard, La.	Wilcox	10¾"-1307'	Dry		Wildcat
12,455	7- 7-45 11- 9-44	Shell 135 Reyes	Domingues, Los Angeles, Calif.	Miocene	16"-963', 10¾"-7000'	Testing		Deep test wildcat
12,469	8- 1-45 6- 2-45	Calif. Co. 2-1 Delta Farms	6-17s-21e, La Fourche, La.	Sandy shale		Dry		29 bits used
12,471	4- 4-45 6-21-44	Gulf 2 A. J. Hamshire et al	Fannett, Jefferson, Texas	Hackberry	20"-122', 13⅜"-3458', 9⅝"-9332', 5½"-12,156'	Dry		Wildcat. 157 bits used

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, +datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

17 More
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DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Compl't'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,483	2-15-39 8-25-38	Texas 1 Continental L & F	Penchant Bayou, Terrebonne, La.	Miocene	13⅜", 9⅝", I"	Dry		Wildcat
12,487 2.77	6-24-41 3-16-41	Humble 1 E. F. Marin	Bayou Sale, St. Mary, La.	Miocene (sand) St. Mary 10,100-10'	20"-214', 13⅜"-3195', 7"-10,940'	211 B 36.5° 179 MCF ¼"	‡1700, °4594, +10,063, 852	Wildcat. 12 perf. at 10,135-8', 9 at 10,072-5', 44 at 10,100-10'. Air lift. came in flowing
12,490 18.95	6- 7-44 3-25-44	Phillips 1 Milian	90-14s-3e, Vermilion, La.	Miocene	16", 10¾"	Dry		Wildcat
12,491	5-15-43 12-30-42	Shell 21-28 Tulare Lake	Tulare Lake Tulare, Calif.		13⅜"-1015', 9⅝"-9738'	Dry		Wildcat
12,491 248	3-11-46 6-16-45	Cont'ntl Magnolia 2 E. R. Bolton	Saron Lake, Trinity, Texas	Rodessa lime Edwards limestone	10¾"-381', 9⅝"-7326', 7"-10,642'	28 B cond. 48.9° 5743 MCF ¼"	‡4194, ^4395, 207,000	Wildcat. 240 perf. at 10,500-40'. Shut in
12,496 15	2-14-45 12-30-44	Hunt 1 St. Mary Bank & Trust	8-15s-12e, St. Mary, La.	Miocene	10¾"-2500'	Dry		Wildcat
12,497	9-30-46 4-24-46	Phillips 1 Roloff	Cameron, Texas			Dry		
12,500	12-21-41 10- 5-41	Amerada 1 St. Martin Ld. Co.	19-9s-8E, St. Martin, La.	Miocene	16"-120', 10¾"-1842'	Dry		Wildcat
12,500		Texas Co. 1 S. G. Jones	Sour Lake area, Hardin, Texas			Dry		Wildcat
12,503 23.6	1-18-44 11- 7-43	Phillips 1 Marias	42-12s-7e, Iberia, La.	Miocene	20" 10¾"	Dry		Wildcat
12,505 44	5- 4-45 12- 5-44	Stanolind 1 A.D. Suderman	Chocolate Bayou, Brazoria, Texas	Lower olig.	20"-90', 13⅜"-2496', 9⅝"-7004'	Dry		Wildcat
12,512	6-25-40 3- 8-40	Gulf 1 Bowie Lbr. Co. Ltd. "B"	Lake Boeuf, La Fourche, La.	Miocene	20"-120', 13⅜"-2018', 9⅝"-8202', 5½"-4421'	Dry		Wildcat. Used 48 bits
12,512	10-22-44 5-26-44	Texas 3 C. G. Hammill	Wm. Baxter sur., Matagorda, Texas			Dry		Wildcat
12,523	9-21-44 4-18-44	Gulf 22 Kirby Lbr. Co.	Cleveland, Liberty, Texas	Wilcox Wx 9042-56'	20"-76', 13⅜"-2030', 9⅝"-7996', 5½"-12,507'	1007 MCF	‡74 ^900	Wildcat. 84 perf. 9042-56'. Completed as gas well 11-17-44.
12,525 52.10	10-28-45 7- 3-45	Phillips et al 1 Neinstelt	20-4s-6e St. Landry, La.	Wilcox		Dry		Wildcat. Topped Wilcox at 11,153'
12,525		Taylor 1-G E. A. Parr	SA & MG Sur. Duval, Texas					
12,527 21.73	2-21-44 12- 4-43	Phillips 1 Vermilion	88-14s-3e, Vermilion, La.	Miocene	10"—10¾"	Dry		Wildcat. Plugged 2-21-44
12,527	9- 5-41 6-12-41	Continental 8 Martha Haas	Ville Platte, Evangeline, La.	Wilcox Wilcox	10¾"-2012', 6"-10,413'	312 B 39.6° 245 MCF, ¼" ch.	§1500-^1400 °4080-795:1	72 perf. 10,128-54'. Prod. form. 26' thick.
12,529		Superior-Union 8 Kern Land	Ventura, Kern, Calif.		13⅜", 7"			
12,529 3075	10-27-46 9-28-45	Cities Service 1 Parker-Wentz	Sec. 20, blk. 44, T&P, Ector, Texas		10¾"-3782', 5½"-12,524'	Dry		Wildcat
12,536	1- 3-46 10-20-45	Union of Calif. 1 I. Delcambre	Tiger Lagoon, Iberia, La.	Miocene		Dry		
12,536 259	12- 7-46 7-13-45	West Prod.-Noranda Oil H.M.Boring	Madisonville, Madison, Texas	Rodessa Edwards 50'	16"-409', 10¾"-2236', 7⅝"-9548', 5½"-12,516'	39 B cond. 54.6° 1053 MCF—¼"	§3300-^3300 27,000:1	Wildcat. 467 perf. 9495-570' (prod.) 9614-30'. Shut in
12,541 100	Drilling 7- 2-46	General Pet. 46-1 La Mirada Com.	La Mirada, Los Angeles, Calif.	Miocene	13⅜"-1037'			Wildcat
12,543 304	11- 4-46 11-19-45	Seaboard SWUM-BVA 73-14	Buena Vista Hills, Kern, Calif.	Upper miocene	13⅜"-1512', 9⅝"-7494'	Dry		Used 170 bits. Drilled to 11,500' in 119 days—fish—new hole
12,557	6- 2-46 2- 1-45	Tide Water 21 McGonigle	Ventura Av., Ventura, Calif.			2269 B 30.8° 12,557 MCF	°3200-‡2850	
12,558	5- 0-45 2-12-41	Shell (Alliance) 3 Hartman Ranch	Ventura, Ventura. Calif.	Pliocene	13⅜"1030', 9⅝"-7365', 7"-10,170', 4½"-12,496'	186 B 89 CF		Deepest producer in Ventura field from 12,558' on pump
12,574	7-30-45 9-14-44	Humble 10 O. P. Buchanan	W. M. Baldridge Sur., Midland, Texas	Ellenberger Strawn 20'	13⅜"-4549', 9⅝"-4789', 7⅝"-8831', 5½"-12,569'	270 B 45.7° 1172 MCF 11/64"	°2950 to 1700 2950 to 350‡	Wildcat. 60 perf. 10,370-90' Init. res. press. 5300 datum—7555
12,581 51	3-15-44 12- 2-43	Stanolind 1 A. L. Holland	G. Robinson Sur., Brazoria, Texas	Middle oligocene	16"-80', 10¾"-1998'	Dry		Wildcat
12,587 11	6-10-44 2-15-44	Humble B-3 Houston Fms. Dev.	Hills Bayou, Galveston, Texas	Frio (shale and sand)	13⅜"-2798', 9⅝"-8586'	Dry		
12,600	9- 5-44 5-14-44	Phillips 1 Robnett	Chocolate Bayou, Brazoria, Texas	Frio		Dry		
12,600 69	2-22-46 3-26-45	General Pet. 1 Lee Brown	La Mirada, Los Angeles, Calif.	Mio (volcanics)	13⅜"-1013', 7"-12,042', 5" liner TD	250 B 28.0°		Wildcat. 80 perf. 12,037-227', 12,257-77', 12,317-527'. On pump
12,600	6-17-40 2-10-40	Humble 1 Caldwell Sugar	115-14s-15e, La Fourche, La.	Miocene	20"-273', 13⅜"-2972', 9⅝"-10,907'	Dry		Wildcat
12,602	9-30-46 7-24-46	Texas 50 State Lake Pelto	Lake Pelto, Terrebonne, La.	Shale Sand	10¾", 7", 5"	86 B 46.0° 1605 MCF	‡2100 18,000:1	Wildcat. 144 perf. 12,397-415'
12,610 1930	12-17-46 1-13-46	Okla. Natural Gas 1 Oakwood Unit	NW NW NW 6-17n-14-w, Dewey, Okla.	Wilcox (12,510-90')	20"-157', 13⅜"-2698', 9⅝"-8430', 7"-9420'	Dry		Wildcat. 2000 perf. 7910-8010'
12,616	10-25-44 8-27-44	Union of Calif. 1 Gaidry	Sec. 22, Terrebonne, La.	Miocene Mio. 10,290-8'	16"-164', 10¾"-2772', 5½"-10,350'	Oil 41.6° 8794 MCF ⅜"-¼"	‡1200-^3700 199,000:1	Discovery well. 23 perf. 10,290-8'. Used 22 bits. Shut in
12,618		Superior 8 KCL	Greeby, Kern, Calif.	Vedder				
12,619	5-28-45	Superior 1 Alex Thompson	21-9n-18w, Jeff Davis, Miss.			60 B 54° ¼"	‡2900	Wildcat

*Location is section or area or field, county or parish, and state.
†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, +datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

Baldwin-Rex Field Engineer

do you know Roller Chain . . .

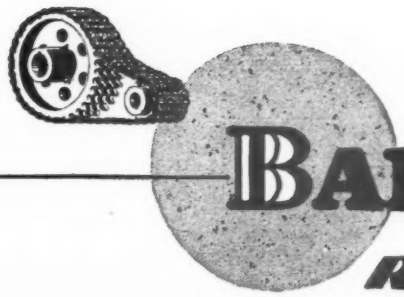
is easy to replace?

● Baldwin-Rex Roller Chain is not only easy to replace . . . it's easy to order for replacement. You measure the pitch . . . the distance from pin center to pin center; count the number of strands; and check the chain number on the side bar. Then order from a local Baldwin-Rex distributor. Be sure, however, to get the correct chain number as indicated in the illustration at left, for roller chain is made in both standard and heavy series. The series are not interchangeable where multiple strands are to be replaced. Heavy Series are indicated by a letter "H" before the chain number.

Baldwin-Rex is built to American Standards Association specifications and is interchangeable with corresponding sizes of other makes of roller chain.

When replacement is necessary, remove the connecting link and uncouple the worn chain. Where possible, use one of the sprockets as a fixture to hold the strand in place during removal. Reverse this procedure in installing the replacement chain.

Baldwin-Rex Roller Chains are for sale in all oil fields. For information, see your Baldwin-Rex Field Engineer, your local supply store or write direct to



BALDWIN·REX

ROLLER CHAINS

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY

38 Plainfield Street, Springfield 2, Massachusetts

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,623 16	2-20-46 10-11-45	Tide Water Assn. 2-C Manhattan Ld. & Fruit Co.	Venice, Plaquemines, La.		24"-105', 20"-219', 13⅜"-2483', 9⅝"-9593', 5½"-12,60'	206 B 38.6° ¼"	‡1650, °3977, •10,800	142 perf. at 10,807-25'
12,628	10- 5-44 5-14-44	Tide Water 86-A-7ShafterCom.	Shafter, Kern, Calif.			Non-commercial		
12,640 147	4-12-45 5- 3-44	Magnolia C-1 Lutcher-Moore	Pine Grove, Beauregard, La.	Wilcox Wilcox	16"-120', 10¾"-4509', 7"-12,165'	5 B 44° 11/64"	‡300	Wildcat. 168 perf. at 11,343-50'. Discovery well Pine Grove field.
12,662	4-15-46 10- 1-45	Sun 1 Rice Ld. & Lbr. Co	32-4s-11w, Beauregard, La.	Wilcox		Dry		Wildcat
12,665		Superior 27-27 Houchin	27-31s-26e, Kern, Calif.					
12,667	2- 1-45 5-27-44	Gulf 2 S. M. Allen, et al	Allen Dome, Brazoria, Texas	Hackberry (olig)	20"-110',13⅜"-3494',9⅝" -7179, 7"3375' 5½"-6300	Dry		Wildcat. 76 bits used
12,674	10-21-45 5-11-45	Richfield A-1 San Emidio	8-11n-21w, Kern, Calif.		13⅜"-1620'	Dry		
12,686 552	6-21-46 9-18-45	Humble 1 Freeman	Brushy Creek, Anderson, Texas	Travis Peak	20"-108', 13⅜"-1692', 9⅝"-5994'	Dry		Wildcat
12,688 69	8-13-42 5-28-42	Continental 2 Pardee Co.	Reddell, Evangeline, La.	Eocene	13⅜"-1000', 10¾"-2013'	Dry		Wildcat
12,689	12-18-43 8-23-43	Texas 5 La. Ld. & Exp.	Bay St. Elaine, Terrebonne, La.	Shale	16", 10¾", 7"	Dry		
12,700	10-29-45 8-23-45	Humble 1 W. & E.N.Kearney	Bayou Carlin, St. Mary, La.	Miocene	13⅜"-2719'	Dry		Proven area
12,702 8204	12-20-45 8-14-44	Calif. & Texas 20 Wilson Creek Unit	Wilson Creek, Rio Blanco, Colo.	Pre-Cambrian Morrison	13⅜"-588', 9⅝"-7239' 7" liner	Dry		Wildcat below 7000'. Completed as gas injection well 6615-723'
12,722	4-20-46 9-19-45	Gulf 18 Delta Securities Co.	Bayou Couba, St. Charles, La.	Miocene	20"-121', 13⅜"-2520', 9⅝"-8165'	Dry		Wildcat
12,726	-38	4 Holstein	Germany					Deepest well outside U. S. in 1938
12,726 16	2-27-46 12-21-44	Gulf 1-A Lacassane Co.	Hayes, Jefferson Davis, La.	Hackberry	20"-139', 13⅜"-2558' 9⅝"-9240', 7"-10,604'	Dry		Wildcat. 94 bits used. 5" casing to 11,175'
12,730 79	12- 1-46 2-13-46	Magnolia 1 Burnet-Granger	Mamou, Evangeline, La.	Wilcox	16"-187', 10¾"-4500', 7"-11,984'	37 B 47.2° 5/64"	°500 3217	12 perf. 11,561-4'
12,735	Drilling	Texas 1 White	Wm. King Survey Freestone, Texas					Wildcat
12,770	3-20-39 8- 1-38	Texas 2 State- Horseshoe Bayou	Horseshoe Bayou, St. Mary, La.		18⅝", 13⅜", 9⅝", 6⅝"	60 B 3 MCF 19/64"	Rock pres. 2800	Perf. 11,829-47', 11,782-804', made 130 B 32.9° on 3/4", 5-28-39. Made 216 B 5-30-39
12,786 2625	5-25-35 3-21-33	Gulf 103 J. T. McElroy	McElroy, Crane & Upton, Texas	Ellenberger Permian	16"-762', 10¾"-4014', 7⅝"-10,301'			Wildcat. First 12,000 test. 718 bits used. In 1946 175 B/D 31°
12,789	7-30-45 2-21-45	Gulf 1 Grief Bros. Coop. Corp. "A"	Bayou Boullion, St. Martin, La.	Hackberry (olig)	20"-90', 13⅜"-1984', 9⅝"-8098'	Dry		Wildcat. Water location
12,792 300.40	5-26-45 1-24-45	Western Gulf 67-6 L. A. A. C.	Paloma, Kern, Calif.	Paloma (miocene) Symons	13⅜"-1277', 7"-12,757'	50B	©2300-‡1900	180 perf. at 11,955-85'. 360 perf. at 11,835-95'. Reperf. 12,757'
12,818	3-22-41 7-24-40	Tide Water E-25-7, KCL	Strand, Kern, Calif.			910 B 33.8° 725 MCF	‡1050	
12,826 112.10	9-21-46 5-31-46	Barnsdall 1 Edge- wood Ld. & Log. Co.	11-6s-10w, Beauregard, La.	Wilcox	16"-105', 10¾"-3050'	Dry		Wildcat. 66 bits used
12,843	1943	California 1 Smith et al	Brookhaven, Lincoln, Miss.	Glen Rose		Dry		
12,855		Texas 1 Kirby Pet.	Chambers, Texas			Dry		Wildcat. Wm. H. Hodges Survey
12,857 322	4-22-42 12- 6-41	Continental 1 Newman	Shafter, Kern, Calif.	Lower miocene Vedder	13⅜"-989', 7"-9892', 5"-9577-12,785'	104 B 37.3° 80 MCF 1"	©980-‡10- §2769,•12,821 769	126 bits used. Abandoned 8-28-43
12,884 692.57	9-12-41 7-18-40	Standard E1- IU	Kettleman No. Dome Kings, Calif.		28"-20', 20"-512' 13⅜" 5700, 9⅝"-7123, 6⅝"-10,865'	Dry		Wildcat. perf. at 11,557-624'
12,895 6974	4-28-46 2-11-45	Mountain Fuel 1 Rock Springs Unit	Church Buttes, Uinta, Wyo.	Morrison Dakota	15½"-288', 9⅝"-6440' 6⅝"-12,879'		§5675-△5550	Wildcat. 231 bits used. 275 perf. at 12,550-12,697'
12,905	10- 1-41 6-18-41	Gulf 192 State 7-La. "PP"	Timbalier Bay, La Fourche, La.	Miocene	20"-110', 13⅜"-2192' 9⅝"-8374'	Dry		Wildcat. Water location. 54 bits used. Abandoned 9-28-43
12,905	1-11-46 1-10-45	Humble 1 C. C. Carlton	Venus W. C., Highlands, Fla.	Igneous	26"-94', 20"-543', 13⅜"-2932'	Dry		Wildcat
12,930	9-15-46 9-26-45	Chanslor-Canfield 1 Bandini	21-2s-12w, Los Angeles, Calif.		16"-1166', 9⅝"-9938', 6⅝" liner 9901-11,131'			Wildcat. Perf. 11,138-12'-12,002'. 57 bits used. Plugged
12,936 317	10-31-41 1-31-41	Continental C-2 KCL	Shafter, Kern, Calif.	Lower miocene Vedder	13⅜"-986', 10¾"-5020', 7"-10,029', 5½"-12,807	488 B 36.8° 500 MCF 25/64"	‡25-§4700, §12,806, 1025	Wildcat. Abandoned 3-7-45
12,940		Lloyd Corp. 18	Ventura, Calif.					
12,946 109	Completing 5-16-46	Pan American 1B Sternenberg Lbr.	J. Dorsey 1, abs. 191, Hardin, Texas	Wilcox Wilcox	16"-94 , 10¾"-3130 , 7"-9880 , 5"-3087	Dry		Semi-wildcat. 35 bits used
12,952	5-14-42 8- 6-41	Union 1 McDonald Unit	Lisbon, Claiborne, La.	Smackover Cotton Valley	16", 10¾", 7"	Cond. 54.7° 50 MCF		PB 11,725
12,955 3740	7-12-45 5-29-44	Imperial 1 Coalspur	Coalspur, Alberta, Canada	Rundle (carb.)	13⅜"-614 , 7"-10,430 , 4¾"-12,776			Wildcat. 422 bits used. 8 sets of perf. at 9350-11,310

*Location is section or area or field, county or parish, and state.
†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, △shut in tubing, •initial reservoir, +datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

MIDWEST

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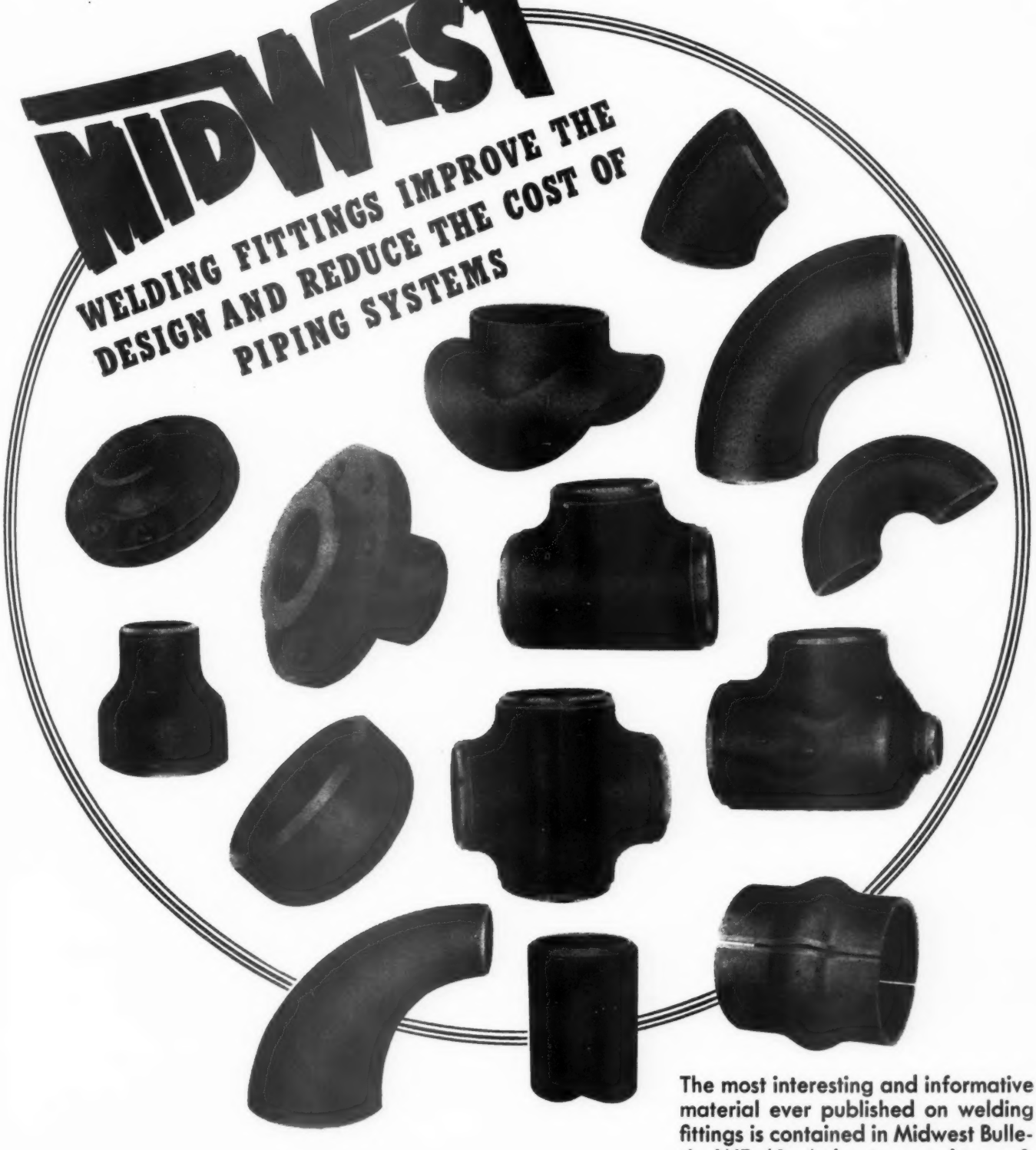

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JONES & LAUGHLIN SUPPLY COMPANY

Subsidiary of Jones & Laughlin Steel Corporation

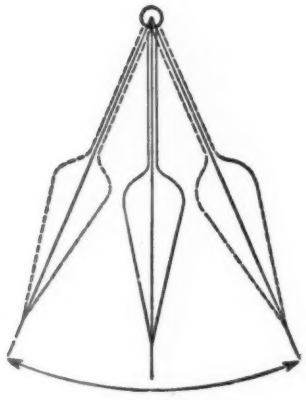
TULSA, OKLAHOMA

J&L STEEL

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
12,955	8-14-45	Superi r-Atlantic 1 McMahon	Montgomery, Texas	Wilcox				Wildcat. Some oil
12,982	3-31-46 12-30-45	Continental 1 Willie S. Patout	Grand Marias, Iberia, La.	Discorbis sand	13⅜"-1512', 9⅝"-9022',	Dry		Wildcat. 55 bits used
12,985	4-29-39 3- 1-39	Union of Calif. 1-36 Kern Co.	Kern, Calif.		7"-12,787'	252 B 32.2°		One of the fastest drilling jobs on record
12,989 290	5-21-39 8-24-38	Calif. Exp. Co. 1 Salisbury	Button Willow, Kern, Calif.	Miocene	36"-22', 30"-85', 18⅝"-1354', 11¾"-5294', 7⅝"-11,472'	Dry (show)		Wildcat. 130 bits used. Abandoned 4-1-40. 4¾" liner 12,812', 3½"-12,716'
12,992	1945 7-22-44	Atlantic 1 Teche	St. Mary, La.	Miocene	16"-164', 10¾"-2450', 5½"-12,377'	76 B		Proven field
12,992 35	7-31-45 3-21-45	Abercrombie-Magnolia 16 Bernard River Ld. Dev. Co.	Old Ocean, Brazoria, Texas		13⅜"-2319', 9⅝"-8906', 7"-10,920'			Injection well. 300 perf. at 10,160-210'
13,000	Drilling	Four Star 1 Corcoran-Irrigation	Kings, Calif.					
13,008	10-16-45 5-21-45	Continental 1 Mrs. A. Dobbertine	Johnson Bayou, Cameron, La.	Discorbis (oligocene)	20"-44', 13⅜"-1779', 9⅝"-8818'	Dry		Wildcat. Perf. at 8983-9004'. 100 per cent salt water
13,011	9-27-45 11-30-44	Gulf 1 J. T. Hooks Estate, Inc.	Hankamer, Liberty, Texas	Yegua	20"-121', 13⅜"-1984', 9⅝"-8288', 7"-2666'	Dry		Wildcat. 91 bits used
13,019	10-16-45 11- 8-44	Tide Water SP-82	Coalinga, Fresno, Calif.			Non-commercial		
13,020 16	4-24-46 1- 1-46	Tide Water 29 Buras Levee Dist.	Venice Plaquemines, La.	1st prod. form. 13,000-13'	24"-102', 20"-214', 13⅜"-2516', 9⅝"-9511', 5½"-13,019'	326 B 38.8° ¾"	‡5100, ^5600, °6535, +13000 1797	Original completion in abnormal pressure zone which declined rapidly in production. Recompleted 11-6-46 at 12,030-39', 12,051-64'. 286 B/D 37.1°. ⅝" ch. 1162 GOR. 1300 tub. press.
13,021	7- 1-46 5-13-46	Continental 4 Calcasieu Lake State	Calcasieu Lake Dome, Cameron, La.	Catahoula	16"-141', 10¾"-1953'	Dry		Wildcat. 43 bits used
13,028 335	4-29-40 1-10-40	Continental 1 Community	Shafter, Kern, Calif.	Lower miocene	13⅜"-1000'	Dry		Wildcat. Tested wet.
13,033		Caribbean Pet. R-801	Zulia, W. Venezuela	Eocene				
13,033	4- 8-46 12-26-45	Gulf 1 Eugene De Armas et al	Grand Bay, Plaquemines, La.	Miocene	20"-110', 13⅜"-2517', 9⅝"-9271'	Dry		Wildcat. 19 bits used
13,064 318	11- 6-38 2-26-37	Continental KCL-C1	Shafter, Kern, Calif.	Miocene	13¾"-1019', 9⅝"-4996', 6⅝"-9147'	Dry		Wildcat. Deepened by Conoco from 10,244'-13,064' in 1938
13,084	9-14-43 5-26-43	Continental 1 Adolph Hebert	Big Lake, Cameron, La.	Miocene	13⅜"-1814', 9⅝"-9500'	240 B Cond. 37.5° 1446 MCF 10/64"	‡2650, °4119, 5900	Wildcat. Perf. at 8571-86'
13,087	Drilling 10-26-46	Shell 3 Smith-State, Unit 1	Weeks Island, Iberia, La.					Smith State 1 and 2 are world's deepest producers
13,124	4-11-39 12-15-38	Standard of Calif. 2 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	30"-7', 16"-1583', 10¾"-8015', 7"-13,040', 5½" 98'	6144 B 36.7° 578 CF 36/64"	°1113, ‡1104	
13,129	1938	Superior	Wasco, Kern, Calif.	Eocene		6528 B 459 MCF 58/64"	°610, ‡520	Second producer from Eocene in Wasco field
13,130	1-14-40 10-20-39	Standard of Calif. 3 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	20"-5', 14½"-1057', 9⅝"-8090', 6⅝"-13,059', 4¾"-94'	3300 B 36.3° 698 CF 32/64"	°1000, ‡975	
13,130	8- 2-40 5-10-40	Standard of Calif. 5 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	20"-8', 13⅜"-1015', 9⅝"-8087', 6⅝"-13,042', 4¾"-103'	3052 B 37.2° 862 CF 34/64"	°650, ‡700	
13,130	1-28-41 11- 2-40	Standard of Calif. 6 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	20"-6', 13⅜"-1012', 9⅝"-8093', 6⅝"-13,041'	3136 B 37.1° 731 CF 32/64"	°625, ‡750	
13,131 281.75	8-28-39 5-29-39	Pacific Western 1 Janssen	Wasco, Kern, Calif.	Vedder Vedder	16"-994', 10¾"-5431' 6⅝"-13,070, 4¾"-13,131'	1500 B 38.4° ¼"		Shut in 3-13-45. Producing water
13,131	3-27-39	Superior 12 KCL	Rio Bravo Kern, Calif.	Vedder				PB 9302'
13,135	5-11-39 1-10-39	Standard of Calif. 8-B2 KCL	Wasco, Kern, Calif.	Vedder Vedder	30"-14', 16"-1483', 10¾"-8088', 7"-13,090', 5½"-72'	6107 B 37.5° 1193 CF 37/64"	°925, ‡965	
13,135	4-26-40 2-17-40	Standard of Calif. 4 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	20"-9', 13⅜"-1009', 9⅝"-8054', 6⅝"-13,071'	3546 B 36.0° 730 CF 33/64"	°750, ‡820	
13,139	10-31-38 6-11-38	Standard of Calif. 1 Mushrush	Wasco, Kern, Calif.	Vedder Vedder	30"-8', 16"-1502', 10¾"-7489', 7"-11,579'	6448 B 36.7° 643 CF 56/64"	°515, ‡600	
13,139 282	4-29-40 1- 1-40	Continental 1 Meyer	Wasco, Kern, Calif.	Lower miocene A-2 sand	13⅜"-990', 6⅝"-11,830', 4¾"-13,059'	2780 B 36.8° 940 MCF ¾"	°170, ‡370, ^950, °1090, §5450, +12850 338	Cumulative prod. 214,256 B. Abandoned 6-15-45
13,141	10-19-46 11-30-45	Gulf 3 Ruth Fleming et al "A"	28-9s-7e, St. Martin, La.	Hackberry (oli.) Hackberry (oli.)	20"-71', 13⅜"-2089', 9⅝"-8984', 7"-11,113'	491 B 33.1° 433 MCF 5/32"	‡1600 881	264 perf. at 10,698-10, 742'. 88 bits used.
13,150	1-20-41 5-12-40	Pacific Western 1 Meyer	Wasco, Kern, Calif.		13⅜"-1004', 7"-11,343', 4¾" liner—13,150'	Dry		
13,150 63.4	2- 9-46 7- 6-45	Humble 1-B Mrs. J. A. Bel Est.	South Alberlin, Allen, La.	Wilcox Wilcox	13⅜"-2507', 9⅝"-9470', 5½"-13,149'	130 B 47.5° 419 MCF 5/32"	‡1050, °6144, +12,589, 3221	Wildcat. 36 perf. at 12,658-62'
13,153 285	3-14-39 12-19-38	Continental A-4-8 KCL	Wasco, Kern, Calif.	Lower miocene A-2 sand	13⅜"-501', 9⅝"-5490', 7"-12,020', 5"-13,076'	4563 B 35.6° 2010 MCF ⅜"	°1000, ‡495, ^1525, §5650, +13,134, 440	97 bits used. 120 perf. at 13,071-153'. Abandoned 12-3-46. Cumulative prod. 489,000 B.
13,158 288	3-11-40 12-21-39	Continental A-5-8 KCL	Wasco, Kern, Calif.	Lower miocene A-2 sand	13⅜"-995', 6⅝"-12,878' 5"-13,124'	890 B 37.1° 192 MCF 36/64"	‡185, ^975, §5360, +13,134, 216	77 bits used. Abandoned 12-3-46

*Location is section or area or field, county or parish, and state.
†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, +datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.



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THE E EA-SY C CANNOT DO THAT

6 ways of using the E-C

1. On Measuring Line.
2. On Sand Line.
3. As a Go-Devil and recovered when changing bit.
4. As a Go-Devil and picked up wth a core-barrel overshot.
5. Run in with a core-barrel overshot when picking up a core.
6. Run inside of bailer in cable tool drilling.

We call the E-C Inclinometer *self-checking* because it's absolutely impossible to obtain any record unless the plumb bob is standing still.

In mechanically operated instruments, misjudgment in setting the timing apparatus may cause a record to be made before the plumb bob comes to rest. It may catch the plumb bob at the very top of its swing or at zero when the hole is inclined—many degrees off. Why take a chance! In the E-C Inclinometer a false record can never be made.

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SPERRY-SUN WELL SURVEYING COMPANY

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DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
13,204 42	4-27-46 6-26-45	Humble 1 W. W. Moore, Jr.	Bonweir, Newton, Texas	Wilcox Wilcox	20"-132', 13⅜"-3025', 9⅝"-8329', 5½"-13,195'	Limited amounts		Wildcat
13,206 264	2-24-46 6- 6-45	Internat'l Ecuador- ian 1 Bajada	Southwestern Ecuador	Upper eocene	13⅜"-1018', 9⅝"-6640', 7"-10,380'	Dry		84 bits used. Second deepest well in South America
13,206 108	9- 9-46 12-10-45	Sun Oil 6 D. J. Sullivan	E. I. Tule Sur. Brooks, Texas	Vicksburg Vicksburg	9⅝"-5712', 7"-9629', 5"-12,180'	93 B 4355 MCF 3/16"		Wildcat. Production depth 10,180'
13,210	6- 3-38 11-27-37	Stanolind 3-B Calcasieu Nat'l Bk.	South Elton, Jefferson Davis, La.	Cook Mt.	20"-79', 13⅜"-1994' 9⅝"-8650', 7"-9503'	Dry		Wildcat. 31 perf. at 8990-98', 41 at 9140-55 40 at 8914-28'
13,213 192	1946	Kings County 1 von Glahn	4-23s-22e, Kings, Calif.		11¾"-640', 7"-12,004', 4½"-1313'			Wildcat
13,253 11	2- 7-43 9- 2-42	Humble B-1 Hous- ton Farms Dev Co.	Halls Bayou, Brazoria, Texas	Frio Frio	20"-146', 13⅜"-2983', 9⅝"-9794', 5½"-10,917'	620 B 46.2° 1003.5 MCF ¼"	‡5790, *8000, *10,258, 8540	Wildcat. Discovery well for Halls Bayou
13,259	7- 4-45 11-16-44	Texas 44 State Lake Barre	Lake Barre Dome, Terrebonne, La.	Fine sand	16", 10¾", 7", 5"	41 B 50° 1627 MCF ⅛"	‡4100	20 perf. at 11,722-788'
13,266 201	10-27-44 4-22-44	Amerada, 1 Waitschies	North Fannin, Goliad, Texas	Eocene	20"-23', 13⅜"-812' 9⅝"-5536', 5½"-12,278'	22 B 40.3°	⊖210, ‡210	Wildcat. 62 bits used.
13,270	9- 3-39 4- 3-39	Fohs 1 Buckley Mahler	DeLarge, Terrebonne, La.	Miocene	20", 13⅜", 9⅝", 7", 5"	Dry		
13,293	1942	Superior 1 McWhorter	N. H. Lake, Montgomery, Texas	Wilcox		160 B	‡1700	
13,300	12-28-45 5-16-45	Humble 1 L. Treadwell	Punta Gorda, Charlotte, Florida	L. cretaceous	26"-35', 20"472' 9⅝"-5558'	Dry		Wildcat
13,300	10-14-45 5-28-45	Texas B-3 Rigolets Fur Co.	La Fitte, Jefferson, La.	Sandy shale Shale	10¾", 7", 5"	276 B 36.8° ¾"	‡1750 935	Wildcat. 132 perf. 10,264-86'
13,321	10- 4-45 Deepened 3- 9-45	Standard of Calif. 1 Elkins	Ventura, Ventura, Calif.	Pliocene		Dry		
13,333	6-26-38 1-30-38	Fohs 1 Buckley Bourg	DeLarge, Terrebonne, La.	Miocene	18⅝", 13⅜", 9⅝", 7", 5"	125 B 50° 3 MMCF 13/64"	‡4700	Discovery well. Prod. depth, 13,266'
13,369	4-20-45 7-14-44	Humble 2 C. M. Armstrong	Tom Armstrong, Kenedy, Texas	Vicksburg	20"-34', 13⅜"-2374', 9⅝"-8018', 7"-11,743'	Dry		Wildcat. 24 perf. at 11,732-38', 64 at 11,- 695-710', 72 at 11,732-38'
13,400 325	2-19-42 7-31-41	Shell 44-14 Canal	Canal, Kern, Calif.	Lower miocene Stevens	13⅜"-991' 9⅝"-9690'	344 B 36.2° 291 CF 26/64"	⊖180, ‡200	Deep test in a proven field. Perf. at 8396-98'
13,409	8-17-38 2- 7-38	Fohs 1 Bay Baptiste	Bay Baptiste, Terrebonne, La.	Miocene Miocene	18⅝", 13⅜", 9⅝", 7"	55 B 50° 250 MCF 19/64"	‡4025	Discovery well
13,417		Superior 1 La Terre	Lake Decade, Terrebonne, La.	Miocene				Discovery well
13,469	1-40-45 4- 5-44	Standard of Calif. 11-44 KCL	18-20s-26e, Kern, Calif.	Eocene Vedder	20"-13', 13⅜"-1526' 7"-11,907', 5½"-1509'	588 B 36.4° 363 CF 26/64"	‡885	PB 11,478'
13,477	11- 6-45 6-14-45	Atlantic B-3 Lutcher-Moore	32-10s-6e Reserve, St. John Baptist, La.	Miocene		Dry		Proven area
13,500	5- 7-46 2- 4-46	Sun-Stand. of Ohio 3 Elizabeth Regan	Egan, Acadia, La.	Frio Frio	13⅜"-1928', 9⅝"-10,684' 5½"-11,977'	188 B ⅛"	‡5150 7824:1	24 perf. 11,874-80'
13,512	10- 6-44 1- 5-44	Humble 2 Gulf Coast Realties	Sunniland, Collier, Florida	Lower cretaceous	26"-111', 20"-769', 13⅜"-1492', 9⅝"-5660'	Dry		Proven area
13,528	4- 5-46 8-23-44	Phillips 1 England	South Tyler, Smith, Texas	Cotton Valley	20", 13⅜", 8⅝", 5½"	Dry		
13,838	4-20-39 9- 1-38	Standard of Calif. 1 Elrich Community	20-29s-26e, Kern, Calif.	Eocene		Dry		Outpost
13,560	7- 8-43 2-14-43	Union Prod. 1 Fitz- patrick & Vizard	De Large, Terrebonne, La.	Miocene	24", 18", 13⅜", 9⅝"-2704', 5½"	162 B 6264 MCF ¼"	^4500	Prod. depth, 13,475-90'
13,561	1946 7-27-45	Texas 1 Bender Estate	Humble, Harris, Texas			Dry		Wildcat
13,577		Sinclair Prairie 1 Shofner	Chapel Hill, Smith, Texas	Eagle Mills Pettit	8⅝"-8083'	157 B cond. 5518 MCF ½"		PB 8083'. Prod. depth 7964-8058'
13,586	3-30-44 1- 1-44	Union Producing 2 Buckley Bourg	De Large, Terrebonne, La.	Miocene	24", 18", 13⅜", 9⅝"-2835', 5½"	518 B 37.4°		
13,610	1940	Superior 3 State	Lake Calcasieu, Cameron, La.			Dry		
13,620 2983	12-15-46 9-29-45	Stanolind et al 1 Kayser Unit	T&P Sur. blk. 43, sec. 34, Ector, Texas	Ellenberger Ellenberger		168 B		Wildcat. 214 perf. at 8495-525' and 8530-58' Pumping
13,642	10-24-41 7-18-41	Union of Calif. 21-33 Pacific States	Rio Bravo, Kern, Calif.	Basement	12¾"-1524', 7"-11,460	400 B 38.9° 260 MCF	⊖1100, ‡1050	
13,644 285	12- 2-38 6- 7-38	Continental A-3-8 KCL	Wasco, Kern, Calif.	Lower miocene	16"-502', 10¾"-5503', 7"-11,550'	Dry		
13,650		Superior	1-29-25, Kern, Calif.	Eocene		Dry		Wildcat
13,666	9-20-43 12- 7-38	Standard of Calif. 12-6 KCL	Greeley, Kern, Calif.	Vedder		Dry		
13,716	11- 9-38 5-29-38	Standard of Calif. 1 8-B KCL	17-27s-24e, Kern, Calif.	Vedder		Dry		Wildcat
13,728	1-30-39 1-28-38	Union Producing 1 Minnie Brown	Aqua Dulce, Nueces, Texas	Yegua	21½", 16", 10"	7883 MCF ¼"	⊖1850, ‡1825	Prod depth 4585-4603'

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by ⊖flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, ⊖initial reservoir, *datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

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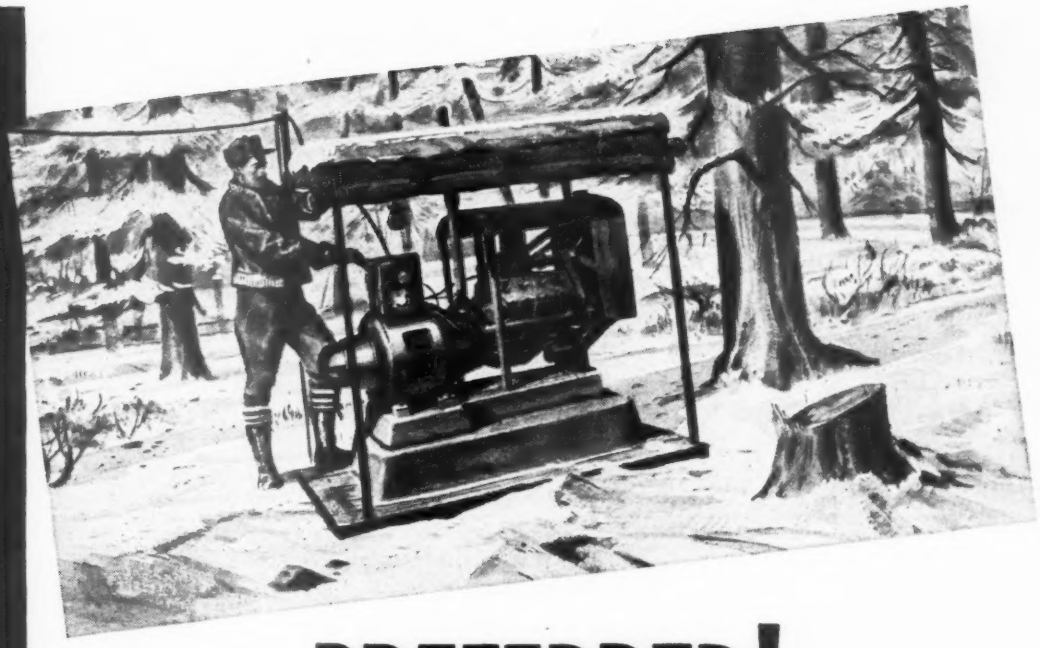
DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
13,747 4664	8-13-46 3-29-45	Imperial-Shell 1 Stolberg	Lsd. 3. 22-41-14w 5th Alberta, Canada	Rundle (Missi)	13⅜"-614', 7"-10,931', 4¼" liner 1588'	2 B high gravity 1000 MCF non-commercial		Wildcat. 600 bits used. In some sections bits could go only few inches. 55 perf. 9750-800'
13,800 75	8-12-46 1-19-46	Magnolia 1 L. F. Duos	Mamou, Evangeline, La.	Wilcox	20"-198', 13⅜"-2352', 9⅝"-8100', 7"-12,115	246 B 47.2° ¾"	‡2875 1951	72 perf. at 11,770-80'
13,815	12-15-46 5-29-45	Stanolind 35-A Hendrick-T88M	Hendrick, Winkler, Texas	Ellenberger Dolomite	20"-256', 13⅜"-2523', 9⅝"-4850', 5½"-13,806'	Dry		Wildcat
13,856 16	12-21-46 2- 4-46	Gulf 1 Calcasieu Nat'l Bk. et al "F"	Hayes, Calcasieu, La.	Hackberry (olig)	20"-134', 13⅜"-2533', 9⅝"-9207', 7"-12,179'	Dry		Wildcat. 47 bits used
13,857 1.7	10-24-46 6-17-46	British-American 1 A.M.Dupont Corp.	Lapeyrouse, Terrebonne, La.	Miocene Sand	13⅜"-2675', 7"-12,303', 3½"-12,076'	111 B 60° 3235 MCF ¾"	‡3840, ^4700, 29,050	Shut in. No P. L. outlet. 36 perf. ⅜" at 12,632-40'
13,873 717	4-13-40 6-19-39	Shell 2A-52-13 KCL	San Emidio Kern, Calif.	Miocene	13⅜"-1616', 9⅝"-10,297' 7"-12,288', 5½"-12,461'	Dry		Wildcat. Perf. at 12,288-460'
13,884	Drilling 4- 5-46	Richfield 1 Buck	A-21-33 Coles Levee, Kern, Calif.		9⅝"-8429', 7"-12,317'			
13,941	11-30-46 7-11-46	Union of Calif. 4-C Louisiana Furs	Fresh Water Bayou, Vermilion, La.	Miocene Miocene	16"-168', 10¾"-2768', 7⅝"-11,929'	Gas (shut in) ⅜"	‡4200	
13,950	Drilling	Beldridge Oil Co. 62-W-33	South Beldridge, Kern, Calif.					
13,957 321	12- -41 9-18-38	Shell B-87-4 KCL	North Canal, Kern, Calif.	Vedder	13⅜"-1108', 9⅝"-9621'	Dry		Wildcat
13,998	9- 7-45 8-23-44	Phillips 4 State Leamex	Lea, New Mexico	Pennsylvanian	20", 13⅜", 8⅝", 5½"	Dry		Wildcat
14,000	Drilling	Texas 6 Yturria	Raymondville, Willacy, Texas					Wildcat
14,020	1939	Superior 1 Helbing	Rio Bravo, Kern, Calif.	Eocene		Dry		
14,021	10-10-46 5- 5-46	Texas 45 State Lake Barre	Lake Barre Terrebonne, La.	Shale and lime Sand	13⅜, 7⅝", 5"	32.46 B 51.8° ⅛"	‡3500	Wildcat. 36 perf. at 11915-24',
14,023 11	4-30-45 9-21-44	Shell 1 State Smith	Weeks Island, Iberia, La.	Miocene Miocene	10¾"-2577', 7"-13,550'	471 B 34° 584 MCF 11/64"	‡2275, °6266, *13,100, 1177	Wildcat. 62 bits used
14,051 362	12- 9-39 4-14-39	Continental D-2 KCL	Bellevue, Kern, Calif.	Miocene	13⅜"-997'	Dry		Wildcat
14,073 2880	9-30-46 6-30-45	Argo 1 Roberts	H&G Sur., sec. 294, blk. 13, Reeves, Texas	Pennsylvanian Wolf camp, calcar'us	9⅝"-478', 7"-5166', 5"-9895'	50 B 44°		Wildcat. 196 bits used. Still testing
14,093 3152	10-20-45 1-15-45	Humble 88-X J. S. Means	Means, Andrews, Texas	Ellenberger	13⅜"-358', 9⅝"-5093'	Show		Wildcat
14,100	10-24-46 2-20-46	Stanolind 4 Franz Huebner	Lucky, Matagorda, Texas	Sloan	20"-92', 13⅜"-2500', 9⅝"-7027', 7"-11,674'	129 B 37.7° 765 MCF 15/64"	°1050, ‡300	Wildcat. 24 perf. at 8938-47'
14,123	1946	Superior 13 KCL	Button Willow, Kern, Calif.					
14,155 49.11	10-17-46 12-26-44	Chanslor-Canfield C-11 Hobson	Rincon, Ventura, Calif.	Rincon	16"-1019', 9⅝"-9368', 6⅝"-13,655'	26 B 27.5° 14 MCF	°2800, ‡130, *6800, 1296	9720 perf. between 8550' and 13,455'. 246 bits used. Prod. depth 13,560'
14,187 21		California 4 E.P. Brady, Unit 4	Alliance, Plaquemines, La.		16"-212', 10¾"-2016', 7"-11,185', 5" liner- 10,955'-14,195'	57B 49.7° 3660 MCF ¼"	‡3075, ^3371, °5153, 64,211	Wildcat. 60 perf. at 9070-82'
14,252 312	4-28-42 9-19-41	General 51-15 SPL	Rio Bravo, Kern, Calif.	Vedder	6⅝"-13,123'	Dry		Wildcat
14,300	Drilling	Gulf 1 State	Lse. 373, 2-67s-29e, Monroe, Florida					
14,301 12	4- 4-46 6-15-45	Shell 2 Smith State, Unit 1	Weeks Island, Iberia, La.	Miocene Miocene	10¾"-2558', 7"-13,430', 5"-14,083'	454 B 33° 587 MCF 15/64"	‡2725, °6429, *13,800, 1294	52 bits used. 67 perf. at 13,763-78'. World's deepest production
14,378	5- 5-43 9- 5-42	Abercrombie-Harrison 1 McDonald	Old Ocean Brazoria, Texas	Frio-Vicksburg	20"-30', 13⅜"-2221', 9⅝"-8916', 7"-12,709'	300 B 52.9° 17/64" 587 B 37.2° ¼"		Dual producer
14,490	12-26-45 2-14-43	Texas 1 State-E. Barataria Bay	Queen Bess Island, Plaquemines, La.	Sand Sand	10¾", 7", 5½"	16 B 53° ⅛"	‡3700	Wildcat. Perf. 11,397-407'
14,512	7-17-44 7- 1-43	Standard of Calif. 2-1 Fillmore Community	24-4n-20w, Ventura, Calif.	Pliocene		Dry		Wildcat
14,577	9-14-46 2-25-46	Texas 2 State Baratoria	Queen Bess Island, Jefferson, La.	Shale	13⅜", 11¾", 7⅝"	Dry		Wildcat
14,582 1890	11- 1-39 8- 3-38	Continental 1 Proctor	Elk City, Washita, Okla.	Pennsylvanian (Bend series)	20"-226', 13⅜"-1477', 9⅝"-10,170', 7" liner to 14,491'	Dry		Wildcat
14,622 916.3	11-21-41 6- 1-40	Honolulu 10-25-P	Buena Vista Hills, Kern, Calif.	Lower miocene Tulare		1700 MCF *¾"	°120, ‡102	Wildcat. Small gas well for several years
14,696 21	9- 3-45 10-11-43	Cities Service and Socony-Vacuum 1 Hillsborough	Prince Edward Island, Canada	Mississippian	13⅜"-995'	Dry		Wildcat. 275 bits used.
14,770	2-10-45 5- 8-44	Standard of Calif. 1 Fullerton	25-27s-23e, Tulare, Calif.	Vedder		Dry		
14,950 105	Testing 10-21-44	Shell 48-A Alamitos	Long Beach, Los Angeles, Calif.	Schist conglomerate	18⅝"-1002', 13⅜"-3512' 9⅝"-7021', 6⅝"-12,853'			Deep test

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, *datum. Last figure without symbol is gas oil ratio in cubic fee tper barrel.



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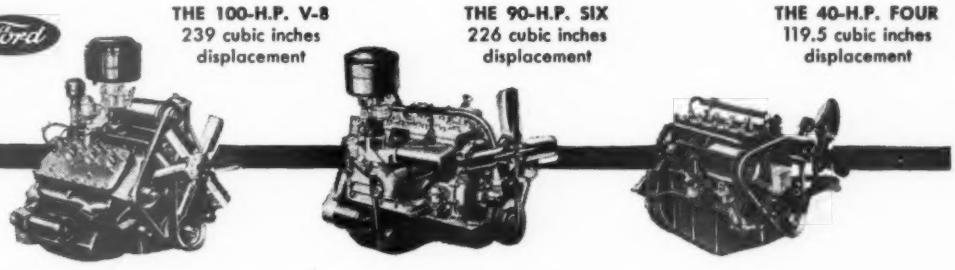

FORD-BUILT ENGINES

FOR INDUSTRIAL AND MARINE POWER

DESCRIPTIONS OF WELLS DRILLED BELOW 12,000 FT.

TD, ft elev.	Complt'd Spudded	Company and well	Location* County, State	Deepest formation Producing form.	Casing schedule	Initial production gravity—choke	Pressure† gas oil ratio	Remarks
15,004 284	4-19-38 6-21-37	Continental A-2 KCL	Wasco, Kern, Calif.	Lower miocene A2 sand	10¾"-5512', 7"-11,573', 4¾"-13,005-996'	3384 B 35.8° 1536 MCF 1"	§1260, ^1350, °5670, •13,134, 454	Wildcat. First 15,000' test. Deepest well and deepest producer at time. Prod. 13175'
15,106	9-21-46 8-22-45	Caribbean Pet. 2A Curacao	Zulia, Venezuela	Eocene				
15,279	2-24-45 6-30-42	Phillips 1 Ada Price	T. C. Railway Sur., Pecos, Texas	Ellenburger	20", 13⅜", 8⅝", 5½"	Dry		Wildcat
15,301	2-16-45 6-20-44	Quintana D-3 S. Texas Syndicate	McMullen, Texas	Edward's lime	9⅝"-15,351'	Dry		Wildcat
15,452 159.46	12- 6-45 12-31-44	Humble 10 E. F. Milo	Tomball, Harris, Texas	Wilcox Cockfield	20"-212', 13⅜"-3002', 9⅝"-8868', 5½"-10,241'	Shut in	°2490, •5870	Wildcat. Six work-overs in 1946
15,730	Testing	Superior 1 Cassie Bradford	SWC SW NW 1-3n- 13w, Forest, Miss.		7⅝"-12,181', 5½"-15,700			Wildcat
16,246	12-27-44 7- 1-43	Standard of Calif. 20-13 KCL	5-21s-25e, Kern, Calif.	Miocene		Non-commercial		Wildcat
16,541	Drilling	Superior 1 Weller	NW NW NE, 11-8n- 12w, Caddo, Okla.					Recently passed 16,671', making it the world's deepest well
16,655 337.90	1945 7-15-44	Phillips 3 Fanny Schoeppe	E. M. Millican Sur., Brazos, Texas	Lower cretaceous	20", 13⅜", 8⅝", 5½"	Gas and oil show Non-commercial		Wildcat
16,668	Fishing 12-31-45	Pacific Western 1 National Royalties	Miramonte, Kern, Calif.					Wildcat. Deepest well in world for 1946. 8⅝" hole largest diameter ever drilled below 13,000'. Deepest core 16,538'-44'

*Location is section or area or field, county or parish, and state.

†Pressure is indicated by °flowing casing, ‡flowing tubing, §shut in casing, ^shut in tubing, °initial reservoir, •datum. Last figure without symbol is gas oil ratio in cubic feet per barrel.

country is still the Cities Service and Socony-Vacuum No. 1 Hillsborough, Prince Edward Island, drilled in 1945 to 14,696 ft.

The United States, however, still leads overwhelmingly in deep drilling, with only eight recorded in other countries. The old one in Germany was drilled in 1938 to 12,726 ft and held the depth record outside the United States for many years.

The states that lead in deep drilling stand in the same order as last year with Louisiana first, California second, and Texas third. Mississippi, Florida, and Oklahoma follow in that order. Louisiana has 144, California 84, and Texas 66 wells 12,000 ft and deeper.

Louisiana and Texas showed percentage increases comparable with the general increase in deep drilling but the number of deep wells in California was up 77 per cent in 1946. The state had 65 up until 1946. Table 3 gives the location according to state and county or by nation.

The descriptions of all wells 12,000 ft and deeper is carried again this year in order to add some items that were not in last year's table. After this the deep holes for the current year only will be published. All 326 deep wells are listed and described as completely as possible. It should be stated that the fine cooperation of virtually all operators has provided the vast amount of data gathered here. It required time and effort for the companies to look up the information, especially in cases where the number of wells owned were large, but it was done promptly and generously.

Some of the questions about wells went unanswered because records had not been kept or were unavailable. A number of companies wrote "no record" for bits. There were, however, enough reports to give some idea of the trends and number used in various localities.

The big record for number of bits used in a drilling operation is still held by Gulf No. 103 J. T. McElroy, the first well to go below 12,000 ft. Operations on the well continued about two years in the West Texas location to reach the Ellenburger at 12,786 ft. A total of 718 bits was used. West Texas still presents some rough work for the drill but most of the deep ones even in this section do not need as many as 200 bits for the operation. There has been a decided improvement in recent years in drilling machinery and equipment adaptable to deep drilling.

The average number of bits used in Louisiana is 67 per well; Texas wells average 91 bits per well, and California 152 bits.

Gulf also has the record low for bits at its No. 1 Eugene DeArmas, Grand Bay field, Plaquemines Parish, Louisiana, where only 19 bits were used. The different conditions between Louisiana Gulf Coast and West Texas has a great deal to do with the difference between 718 and 19 but there is also the difference of 11 years, the DeArmas well being drilled in 1946. Eleven years of advancement in deep drilling methods and improvement of machinery and tools.

Costs on these deep wells would make a teetotaler zigzag. The average comes to a small fortune and the high ones make the average look small. The average estimated cost of the 326 deep wells considered here is about $250,000. The range is from $89,000 up to close to a million dollars, the greatest number of wells costing from $100,000 to $200,000.

There are many unusual circumstances that increase the cost of deep wells. One is the fact that they are usually wildcats and as such are spending for experience in deep drilling or knowledge of deep formations. A level penetrated by only 326 wells is sketchily known to say the least and methods are far from standard. Certainly a fishing job at 16,668 ft, such as Pacific Western has now in Kern County, is more expensive that it would be if the hole were 5000 ft. If the well is a wildcat in shallow as well as in deep formations, it is more expensive to bring in the extra equipment needed for a deep well.

All other things being equal, however, it is possible that greater proficiency and better machinery would have offset the extra costs of deeper drilling. That is, when the drill first went below 5000 ft in 1909, the cost in equipment and labor was probably comparable to the cost of going below 12,000 ft today if the change in dollar value is considered.

The advance in cost is demonstrated by the average in 1946, which was $337,000, much higher than the general average despite the fact that machinery and operators are better adapted to deeper drilling. Actually the pioneers in deep drilling today are spending comparable sums to those who went below 5000 ft back when it was as wonderful as going below 16,000 ft today.

There is a very good reason, however, for Louisiana to have the largest number of deep wells. The cost is less than anywhere, an average of $230,000, California, as in the number of wells, is second with an average cost of $333,000, and Texas is third with an average of $361,000 per well below 12,000 ft.

St. Marys Parish, for instance, can be drilled below 12,000 ft for about $153,000; Vermilion Parish for about $188,000. The famous Wasco field producers in Kern County, California, cost approximately $200,000 but that was almost prewar.

Whatever the cost, it is evident that oil operators are determined to find out what lies in the depths of the earth and their discoveries will be continued to open new possibilities for the industry and the nation. ★★★

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Petroleum substitutes:

Past and present research, development, and economics

By **HARRY H. POWER***

EXCLUSIVE

THE relationship of declining oil and gas reserves to substitutes for petroleum products has been brought to a focus in recent years, prompted primarily by the particular requirements of the United States in times of national emergency. Such an emergency may justify the exploration of these reserves if only to supplement the accelerated but temporary demand, although the cost of producing substitutes under ordinary peacetime developments may be prohibitive. Adequate plans should be prepared well in advance of an emergency for the additional manpower, equipment, and time element necessary to establish satisfactory processes and products.

The choice of petroleum substitutes is essentially an economic one, and will depend primarily on the availability of crude oil and natural gas either at home or abroad at current or higher prices. These auxiliary reserves will not be available under peacetime conditions until substitute products are obtained from them at no greater price than that paid for the corresponding products from crude petroleum. If the United States Government subsidizes petroleum products from coal and shale, some of this oil will become available as a result of the plants constructed and the technology developed.

A review of the literature indicates that the most probable sources of substitutes are: Coal, oil shale, tar sands, natural gas, and agricultural products. Everything else being equal, the less the number of steps through which the raw materials must pass in their transformation into gasoline and other finished products, the simpler and more economical will the manufacturing process become. As an example, if liquid fuel is to be processed from coal, the latter may be converted to a liquid hydrocarbon first by the involved and costly process of hydrogenation. The cost of manufacturing hydrogen alone for this process is an important item. The liquid product must then be separated into desirable and undesirable products by fractionation and further refined. It may therefore be said that petroleum, as a source of gasoline, is two steps ahead of coal in the process described[20].

Although significant progress has been made in recent years to bridge the gap between pilot and full-scale operations, the data on the several processes, which have been gathered from various sources, are far from complete. Extensive research of pilot-plant scale has been done on the hydrogenation of coal and the modernization of the original Fischer-Tropsch synthesis. Unfortunately, the data on the older European operations do not afford a satisfactory basis for the purpose of projecting commercial operations in this country. Although shale-oil research is under way on a greatly accelerated scale, the extrapolation of the old plant data does not give estimates comparable to the data impending from plants of commercial capacities. The yields and costs for the so-called "tar sands" operations need clarification and extension from further large-scale operations. Petroleum fuel substitutes from agricultural products have been omitted entirely from this article because of their relatively high cost, although notable progress has been made in this field in recent years.

New material concerning methods and costs incident to the manufacture of substitutes from auxiliary reserves will not be found herein. An attempt is made, however, to trace the development of each process *broadly*, and compare investments, yields, and unit costs of production for the principal product, motor fuel, resulting from full-scale operations. The costs of substitute gasoline are only of broad significance, for they do not include such items as transportation and the cost of marketing the by-products. The investment figures are only roughly indicative, for it was necessary to compare plants of different capacities, some of which were obsolete. It may be said, however, that the data, such as it is, together with the estimates of reserves of source materials, present a broad picture that may be of assistance in forming at least a tentative conclusion concerning the relative order of impending competitive importance of the several processes.

● **Hydrogenation of coal.** Solid fuels such as lignites and coals may be transformed into finished liquid fuel by a variety of reactions occurring simultaneously and to varying extents in the general process known as hydrogenation. The raw materials and finished products alike are very complex mixtures of relatively unknown composition. The final products may meet all the required specifications, which are sometimes more physical than chemical in character[1].

Catalysts, such as the oxides or sulphides of molybdenum, tungsten, and chromium improve the velocity of hydrogenation one hundred or more times the values existing without catalysts. They must operate on liquid, solid, or gaseous materials and cause impurities such as sulphur, oxygen, and nitrogen to be detached from molecular linkages. The catalyst must accelerate cracking reactions as well as hydrogenation in proper proportions during the conversion of heavy, non-volatile materials into hydrocarbon liquids such as gasoline. Hydrogenation proceeds smoothly and effectively under the proper coordination of temperature, pressure, and catalyst[1].

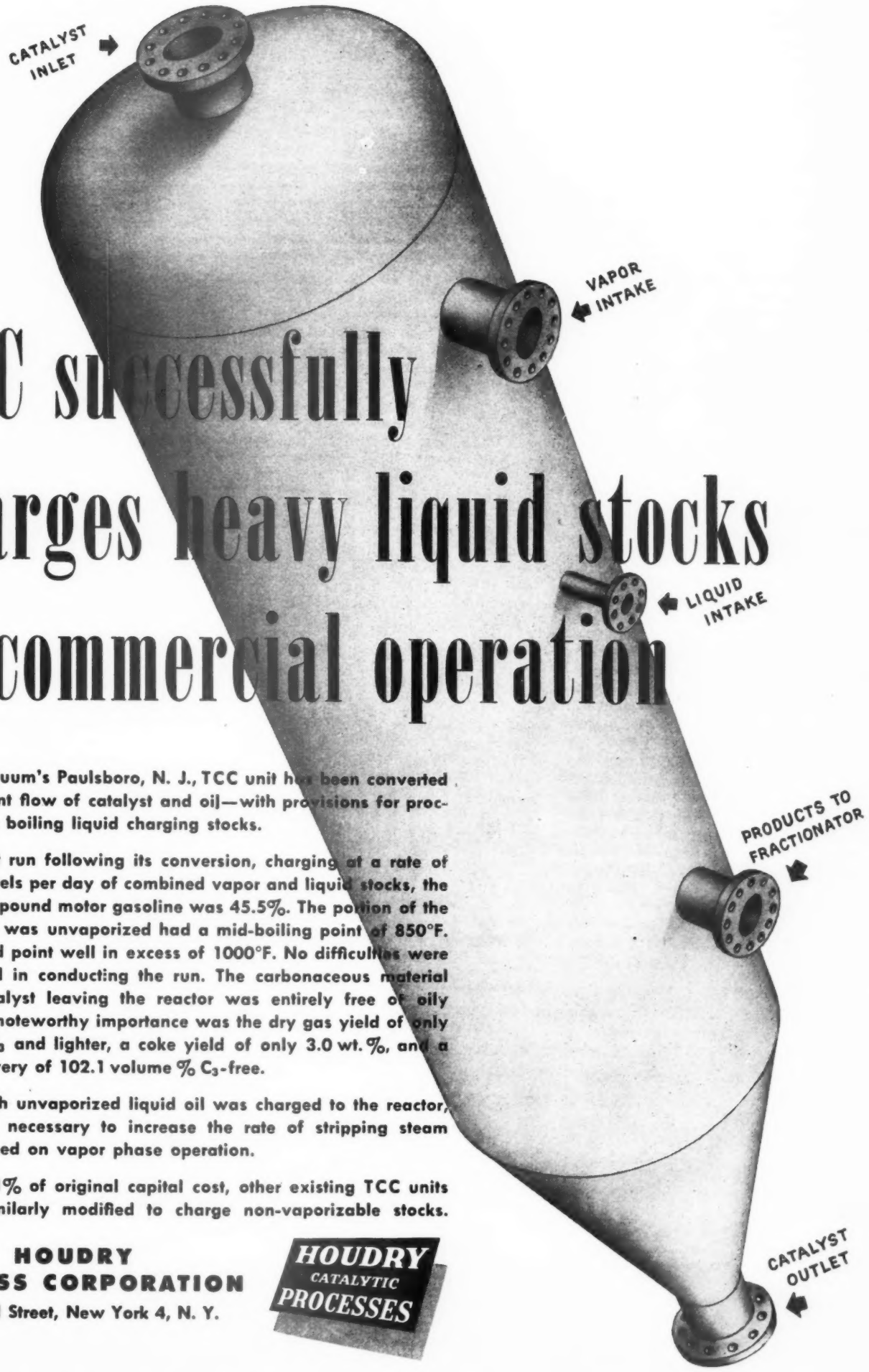
Hydrogenation processes are divided into: (1) Liquid-phase reactions, and (2) gas-phase reactions, where the light oil exists in the gaseous phase during hydrogenation. The hydrogenation of coal as a special application of the liquid phase process will be described[1].

A mixture of finely ground coal, high boiling or *pasting* oil, and minutely divided catalyst is pumped through heat exchangers into a reaction chamber. Eventually the particles swell and dissolve partly after partial hydrogenation, resulting in a mass almost completely liquid. Heavy high-boiling oils formed at first are cracked into lighter oils, gasoline, and gas, at temperatures varying from 750 to 850 F, and pressures ranging from 1000 to 5000 psi. The heavy pasting oil is recovered unchanged.

As shown by a typical flow sheet, the finely ground coal, heavy oil, and catalyst are mixed as a viscous paste, which is pumped through the preheaters to the reaction chamber. The vapor fractions and some of the pasting oil, together with the hydrogen, are next removed in the hot separator. The residual high-boiling oils, ash, a small amount of unchanged coal, and the catalyst then pass to the residue recovery unit where the oil is separated from solid particles and recycled for use with fresh coal. The gasoline formed in the liquid-phase reactor is pumped to the distillation units, and the light oils are conducted to the gas-phase process for conversion into gasoline.

According to Fieldner[19], Bureau of Mines experiments have covered a wide range of coal rank, including peat, brown coal, lignite, subbituminous coal, and bituminous coal, and indicate that hydrogenation under optimum conditions yields high percentages of hydrocarbon liquids from each coal named. Actually, subbituminous coal is the one used chiefly in present processes. Certain difficulties in operation are met in the use of anthracite and bituminous coal.

*Professor and Chairman, Department of Petroleum Engineering, The University of Texas.



TCC successfully charges heavy liquid stocks in commercial operation

Socony-Vacuum's Paulsboro, N. J., TCC unit has been converted to concurrent flow of catalyst and oil—with provisions for processing high boiling liquid charging stocks.

On the first run following its conversion, charging at a rate of 10,000 barrels per day of combined vapor and liquid stocks, the yield of 10 pound motor gasoline was 45.5%. The portion of the charge that was unvaporized had a mid-boiling point of 850°F. with an end point well in excess of 1000°F. No difficulties were encountered in conducting the run. The carbonaceous material on the catalyst leaving the reactor was entirely free of oily matter. Of noteworthy importance was the dry gas yield of only 3.9 wt. % C_3 and lighter, a coke yield of only 3.0 wt. %, and a liquid recovery of 102.1 volume % C_3-free.

Even though unvaporized liquid oil was charged to the reactor, it was not necessary to increase the rate of stripping steam formerly used on vapor phase operation.

For about 1% of original capital cost, other existing TCC units can be similarly modified to charge non-vaporizable stocks.

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Although the yield from lignite is lower, its utilization after the depletion of subbituminous coal is indicated.

In general low-ash coals nearly free from fusain and opaque attritus lend themselves to almost complete liquefaction. In explanation, fusain is the black fibrous, charcoal-like material found in various ranks of coal; opaque attritus is the ground mass of plant debris that may be translucent, opaque, or of various gradations between these limits[19].

Gasoline, highly aromatic in composition, of 70-75 octane number results from the high pressure hydrogenation of subbituminous coal. In terms of barrels of gasoline, it has been stated that one short ton of high-volatile bituminous coal will yield from 1.43 to 1.79 bbl, whereas the same amount of subbituminous coal will yield about 1.11 bbl. One short ton of lignite will yield approximately 0.8 bbl of synthetic gasoline[2].

The known reserves of subbituminous coal in the United States have been estimated to be 818 billion net tons, whereas the reserves for high-volatile bituminous coal and lignite have been estimated to be 1351 and 939 billion net tons, respectively. Hence, a reserve of at least 3108 billion bbl of gasoline based on a conservative yield of 1 bbl per net ton is indicated.

Eighty-five per cent of the subbituminous coal is deposited in Wyoming and Colorado, and almost all the lignite is in Montana and North Dakota.

In accordance with testimony given in recent years[2], operating costs, including depreciation, for coal hydrogenation plants using coal at $2.75 per ton, would range from 15.5 cents per gal for a 30,000 bbl per day plant, to 22.6 cents per gal of gasoline for a 3000 gal per day plant. Other recent literature shows cost estimates ranging from 10 to 25 cents per gal of gasoline, although the lower figure is based upon processes realizable only by extended future research.

It has been estimated that the combined investment required for a number of plants to produce from 3000 to 30,000 bbl a day of gasoline would range from $750,000,000 to $1,280,000,000. A single 1750-bbl plant has been estimated to cost about $50,000,000 based on 1943 price levels. Compared with the investment required for usual gasoline-from-crude-oil refining operations these figures appear to be greatly in excess[2].

Fieldner emphasizes that investigations in the future should be made on units of commercial scale when using American coals. The exact time when hydrogenation processes can operate in this country without subsidy cannot be predicted[19].

● **Coal carbonization.** Fieldner has estimated[2] that the average yield of gasoline per ton of high volatility bituminous coal in a simple carbonization process would be at least 10 gal. Direct hydrogenation of the coal without carbonization was estimated to yield about 60 gal of gasoline per ton.

A low-temperature carbonization plant with cracking facilities capable of producing 1000 bbl of gasoline per day has been estimated by Carter[2] to cost about $1000 per bbl of gasoline per day, or a total of $4,000,000. Six gallons of 70+ octane gasoline was estimated per ton of coal; also 0.67 ton of smokeless fuel and 10 gal of phenols. The 6 gal of gasoline, it was stated, would be produced by cracking 15 gal of the neutral tar to coke.

The cost of carbonization, according to Carter, would be $2.50 per ton of coal, the latter costing $1.55 per ton. On the value basis of $4.25 per ton of smokeless fuel, 94 cents per bbl of oil, and conversion of 40 per cent of the tar to phenols, it was estimated that the 6 gal of gasoline per ton of coal produced would cost about 10 cents per gal. An extra gallon of benzol recovered from the carbonization gases raised the total motor fuel yield to 7 gal per ton.

It is thus seen that the oil and gasoline yields for carbonization are lower than those of other processes, but that the costs per gallon of gasoline might compare favorably with costs existing for the hydrogenation processes. In addition, there would be the possibility of utilizing the large quantities of coke produced in the Fischer-Tropsch synthesis.

● **Shale oil.** An oil shale may be described as an argillaceous shale containing "kerogen." Kerogen is neither petroleum nor bitumen, but a pyro-bitumen yielding petroleum and nitrogenous compounds on distillation. Oil shales contain negligible oil or hydrocarbons that can be removed by ordinary solvents such as carbon tetrachloride; however, oil is recoverable from oil shales by destructive distillation.

Reserves. The reserves of oil shale and oil producible from oil shales have been estimated at 400 billion tons and 100 billion bbl respectively[11]. According to Kraemer's estimates, oil shales in Utah, Wyoming, and Colorado may yield 75 billion bbl, whereas the shales in Kentucky and Indiana have an estimated oil reserve of 17 billion bbl.

Winchester[12] classfied oil shales into: (1) Tertiary oil shales of the Rocky Mountain region; (2) Devonian black shales of the Eastern States, and (3) the cannel shales of the Eastern States. Since Winchester's survey, large Ordovician oil shale deposits have been discovered in Nevada[2]. Oil shale deposits of more limited extent also exist in Texas, Tennessee, Alabama, Montana, and elsewhere.

Processing oil shale. Many difficulties met some 25 years ago[11] in retorting and otherwise processing oil shale have been overcome as a result of the Socony-Vacuum process developed in recent years. The shale is preheated at 500 F in a vertical retort by the countercurrent flow of hot gases that sweep out the oil vapors. In contra-distinction to the former batch processes with the attendant problems incident to the shale sticking in the retort, the new method is continuous. The crushed raw shale passes down the tower by gravity countercurrent to the heated gases passing upward and the temperature of the shale is thereby raised to 1000 F. Oil vapors and

TABLE 1. Summary of Fischer-Tropsch synthesis.*

Process	Estimated reserves in U. S.		Size of plant, bbl gasoline per day	Total investment	Investment cost per bbl gasoline per day	Operating costs (including depreciation)	
	Bbl oil	Bbl gasoline				Per bbl oil	Per gal gasoline
Coal hydrogenation		3100 billion (12)	1750	$50,000,000	$28,500		22.6-15.5c (1)
Coal carbonization		322 billion (12)	1000	$4,000,000	$4000	$0.94	10c (2)
Oil shale	100 billion		500-540 (4)	$5.8 million-9 million	$11,600-$16,700 (3)	$1.75-2.00	9.7-10.7c
Tar sands	275 billion (11)		3000	$8,000,000	$2670	$0.75	Compete with gasoline from crude oil (5)
Fischer-Tropsch:							
European process using coal		4000 billion (10)	6000 (6)	$45,600,000 (6)	$7600		19.2c (7)
European process using natural gas		15 billion	6000 (6)	$28,500,000 (6)	$4750		8.8c(8)
Future American process using coal		4000 billion (13)	....	....	....		6.0c (9)
Future American process using natural gas		15 billion (14)	6000	$20,000,000	$3,330		5.25c (8)

(1) Coal at $2.75 per ton.
(2) Coal at $1.55 per ton.
(3) Calculated from data given in cols. 3 and 4.
(4) Based on ave. est. 10 per cent yield gasoline from plants prod. 5000-5380 bbl shale oil per day.
(5) Crude oil from Turner Valley refined in same area.
(6) Extrapolated values.
(7) Coal at $2.75 per ton.
(8) Natural gas at 5 cents per M cu ft.
(9) Coal at $2.00 per ton.
(10) Reduced to 2,000 billion if coal most suitable were utilized.
(11) Total in Western Hemisphere.
(12) From 1351 net tons of high-volatile bituminous coal yielding 10 gal gasoline per ton—simple carbonization.
(13) Same as for European process, but increased efficiency of American process may increase this.
(14) Same as for European process, but increased efficiency of American process may increase this.

*Note: For details concerning costs refer to text.

escaping gases leave the top of the retort, and oil is recovered in a series of condensers. Spent shale is withdrawn at the bottom. In order to cool the spent shale and recover heat for retorting, the low pressure steam is introduced just above the spent shale drawoff.

Yields. Core drilling at the Bureau of Mines oil-shale mine near Rifle, Colorado, shows that the full 500-ft section of the top oil shale measure averages 15 gal of oil per ton[23]. Large areas of the formation having less than 100 ft of overburden can be exploited by open cut methods. It is estimated that the 500-ft measure contains 300,000,000 bbl of oil to the square mile. The lower 380 ft of the measure yields 17 gal per ton, and the bottom 70 ft yields 29 gal per ton. The yield increases to 50 gal per ton for a high grade 10-ft interval. An underground mine is now ready to supply oil shale to the retort plant from the 70-ft series, which presents the best opportunity for commercial exploitation.

Crude shale oil from experiments performed by Socony-Vacuum[11] is very waxy, highly unsaturated, and has a high sulphur and nitrogen content.

Reeves and Winchester reported the following data from shale-oil distillation[11]:

	Per cent
Colorado shale-oil	
Gasoline	6–12
Kerosine	28.5–49
Paraffin	1.63–7.70
Asphalt	0.47–3.62
Indiana shale-oil	
Distillate to 150 C	17.75
150-200 C	11.75
200-250 C	17.75
250-300 C	16.00
Above 300 C	8.50
Coke and tar	28.25
	100.00

Miscellaneous properties:

Unsaturates	55
Pyridines or pyridine compounds	2–5
Phenol	0–0.5
Creosols	1–2
Sulphur compounds	2–3
Average specific gravity	0.8900
Heat of combustion, Btu	19,200

Economics. It has been estimated that mining and crushing the shale will cost about $2.20 per ton, which is too expensive for commercial use unless a shortage of crude should increase the price of oil to $3.75 or $4.00 a bbl[11].

Kraemer[11] estimates the capital requirements for an oil shale mine and retort to produce 5000 bbl shale oil per day as follows:

Basing the operations in the Naval Oil Shale Reserve No. 1 at Rulison, Colorado, 10,000 short tons of oil shale would be mined per day from the 106-ft bed; 6250 short tons would be mined daily from the 44-ft bed. The 6250 short tons of shale would yield 5000 bbl of shale oil per day, and the 10,000 short tons from the 106 ft bed would yield 5380 bbl of shale oil per day. Following are the estimates of the capital investment for the two programs at Rulison[11]:

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"Tank bottoms" material in oil storage is not subject to oil production taxes, the Court of Civil Appeals of Texas has ruled.

Affirming a Travis County district court, the appellate court declared that oil run into storage is taxed, and that "tank bottoms" reclaimed by cleaning come within the definition of basic sediment. About 20 per cent of the residue material is paraffin suitable for selling to wax companies, and the remainder is sludge, the opinion explained. The case was styled State of Texas versus J. A. Stack.

	Size of operation	
Shale to be retorted, tons a day	6250	10,000
Oil to be produced, bbl a day	5000	5,380
Yield, gal per ton	34	23
Capital invested		
Mining	$1,300,000	$2,100,000
Retorts	3,500,000	5,500,000
Other	1,000,000	1,400,000
Total	$5,800,000	$9,000,000
Per ton of shale a day	$ 925	$ 900
Per bbl of shale oil a day	1,160	1,670

The above calculations were based on shale oil production only, and did not consider cracking, further refining, etc.

Based on the above capital costs as estimated by Kraemer[11], amortizing the cost of the retorting equipment in ten years, and allowing for maintenance, it was estimated that the total cost per barrel of shale oil would be $1.75 when mining 6250 tons a day from the 44-ft bed. The cost per barrel would be increased to $2.00 when mining 10,000 tons a day from the 106-ft bed. The smaller capital investment necessary for processing the richer shale from the 44-ft bed overbalanced the economics in large-scale mining of the thicker and leaner beds.

Kramer[2] has estimated that the cost per gallon of finished gasoline from oil shales, based on Colorado experiments prior to 1929, varies from 9.7 to 10.7 cents per gal. Advances in refining technology are thought likely to offset increases in construction and labor costs since that date.

The present 5 year program of the U. S. Bureau of Mines is designed to show by full-scale operations the economic possibilities of shale oil in competition with the usual oil refinery products. In addition to the $1,500,000 demonstration plant being built on Naval Oil Shale Reserves in Western Colorado, a $500,000 oil shale research laboratory is under construction at Laramie, Wyoming.

● **Tar sands.** The so-called "tar sands" are surface or near-surface accumulations of hydrocarbon residues and for the most part of Cretaceous and Tertiary age. Except for the tar sands of Alberta, Utah, and Colorado, the deposits appear to be petroleum residues, the light fractions of the original hydrocarbons having apparently evaporated with subsequent oxidation of the heavier residue. It is evident that the tar sands in northeastern Utah and nearby in Colorado did not contain liquid petroleum originally. As an explanation, it has been suggested that oil escaped from traps exposed by erosion, and settled in and was transported by streams as small masses of asphalt mixed with sand and other debris. Deposition of these materials formed beds of sand, pebbles, and conglomerate with their included asphalt[21].

The greatest deposits of bituminous rock known are the Athabasca tar sands in Alberta, Canada. The tar content has been suggested to be a product intermediate to vegetable debris and petroleum, for it is difficult to say from the geological relations that the tar was at any previous time a true petroleum[22].

Reserves. Russell[2] has estimated the total oil reserves in known "tar sands" in the western hemisphere as 38.5 billion tons, or about 275 billion bbl.

The greater part of the Athabasca tar sands are buried beneath 500 to 1800 ft of overburden, which would make the cost of mining excessive. Exposures along the Athabasca River system reveal a minimum areal extent of 1000 square miles[18]. The total extent is estimated to be many times greater than this known minimum. From 10 to 20 square miles of the deposits, estimated to contain from 500 million to one billion bbl of oil, are possibly susceptible to open-pit mining.

Large tar sand deposits are found in California, and consist of massive formations of oil shales and silts with bituminous sands and sandstones.

Recovery process. The first operation in the recovery of oil from tar sands consists of mixing and heating the bituminous sand with water to form a pulp. The second operation involves the placing of the pulp in hot water so that the oil will float to the surface as a froth. The sand included originally in the pulp sinks. In a third operation, the high water, sand, and silt content of the oil froth is eliminated. Higher temperatures, mechanical mixing, and neutral to alkaline conditions accelerate the displacement[18].

The water and mineral content of the froth may be eliminated by evaporation. This process is complicated by the property of the wet oil to foam, and also requires an excess amount of heat. Another method is to cut the oil froth with a light oil. The latter breaks the water-in-oil suspension, reduces the oil gravity to a value below that of the water, and reduces the viscosity. All this promotes settling of both water and mineral matter[18].

Oil yields. About 0.92 bbl of oil per ton of sand has been recovered from one operation in Athabasca[13]. The refined products from this crude are a high sul-

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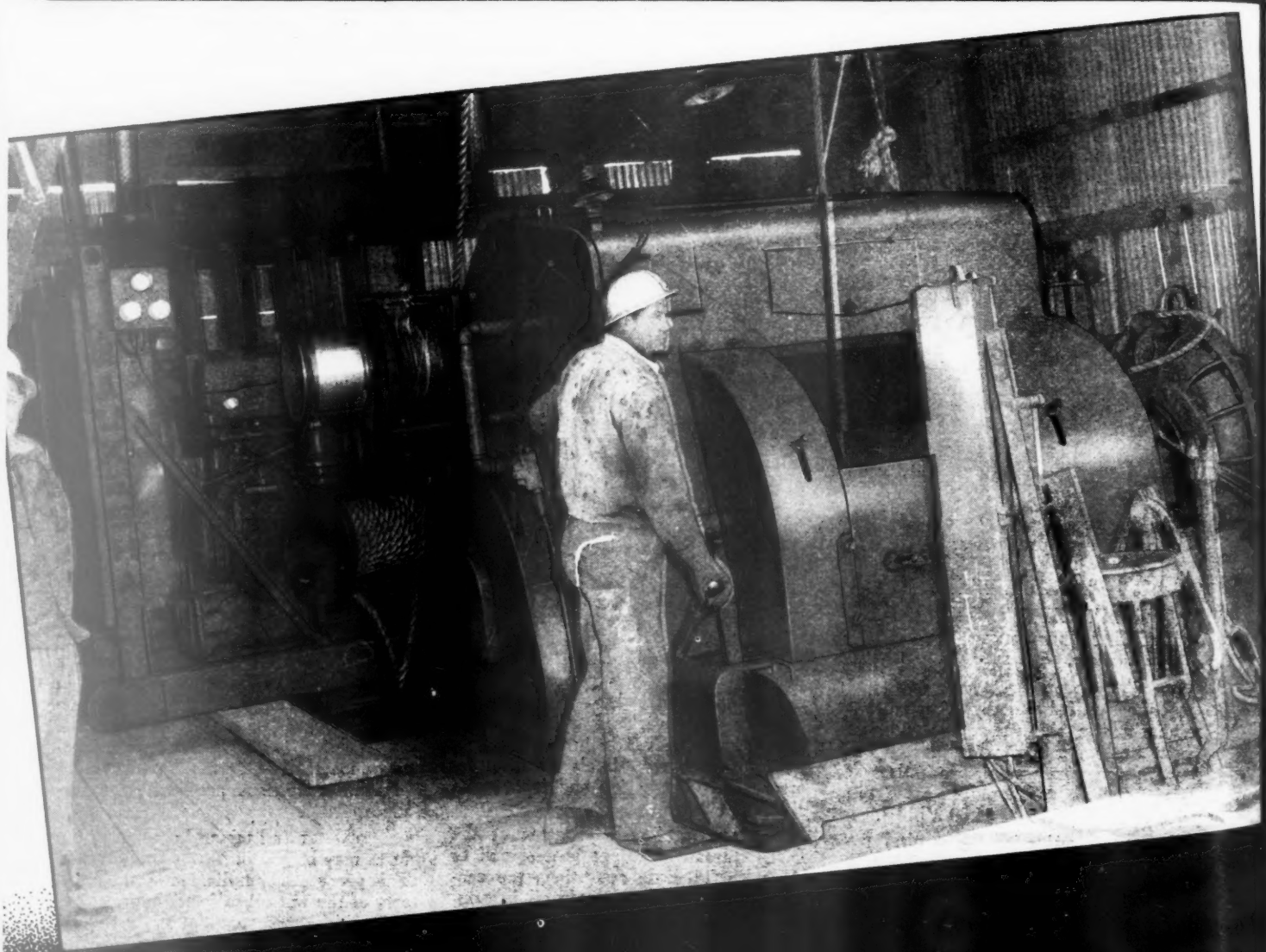

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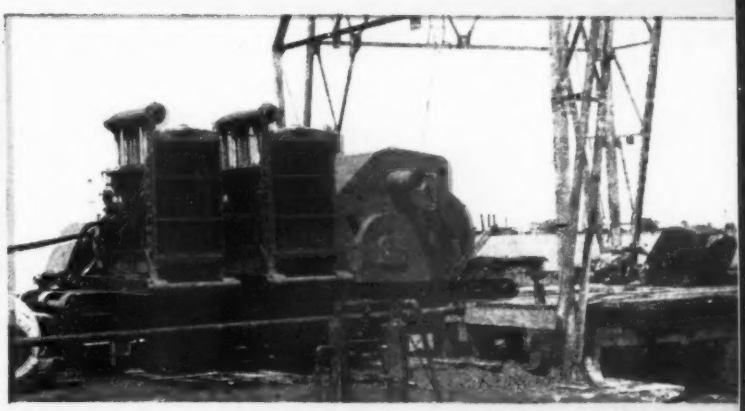

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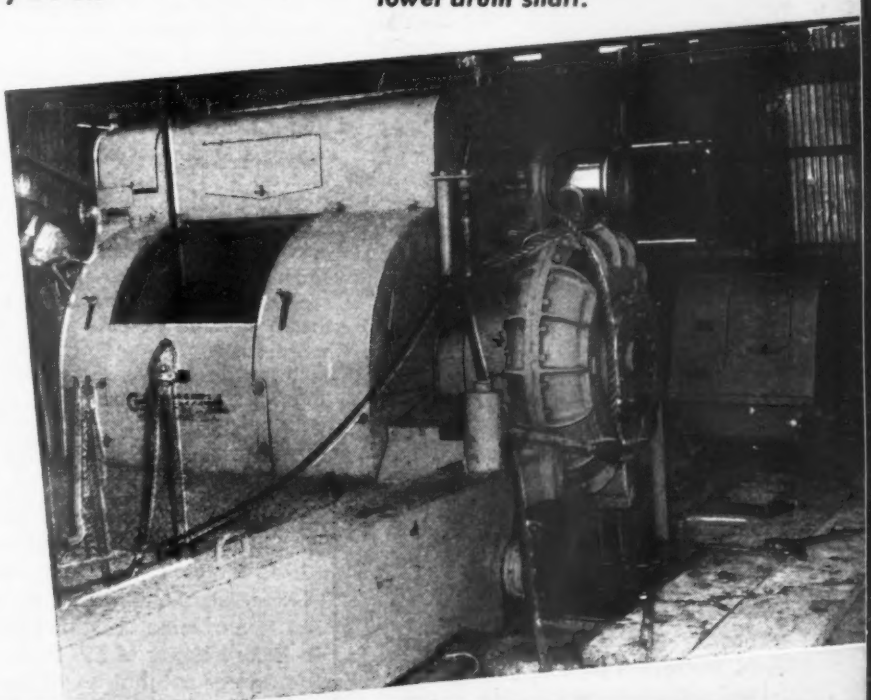

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phur gasoline, together with diesel oil, fuel oil, and asphalt[18]. The yield of gasoline has varied from 25 to 35 per cent without pressure cracking. Small-scale experiments suggest that ultimately a high yield of 80-octane gasoline may be produced[14]. Research on hydrogenation, thermal cracking, and catalytic cracking of tar sand crude has been reported from several laboratories in the United States.

Costs of production. On the basis of a plant proposed to be situated in Edmonton and to produce 10,000 bbl of oil per day, it has been stated[14] that the cost per gallon of 75 to 78-octane gasoline resulting would compete with gasoline at Calgary made from Turner Valley crude oil. It has also been estimated that these operations should result in crude oil at about 75 cents a bbl at the refinery.

The Canadian Government has built a plant, although it has been reported that officials are not satisfied with its equipment and operation. The Provincial Government is reported to be designing and building another plant of different design. The next episode in the bituminous sand development will apparently depend upon the results obtained at these two government plants[18].

Investment. In 1941, Max W. Ball[16] of the Abasand Company, estimated that a 10,000 bbl per day plant to produce 20-22 deg API crude oil would require an investment of about $4,850,000. An additional $4,150,000 would be required for a refinery to process the crude, making the total investment about $9,000,000.

● **Fischer-Tropsch synthesis.** The Fischer-Tropsch process to produce synthetic liquid hydrocarbons[8] appears at first glance to be similar to the synthesis of methane discovered in 1902 by the French chemist Sebatier in accordance with the following equation:

$$CO + 3H_2 = CH_4 + H_2O + 59.8 \text{ Cal.}$$

Sebatier used catalysts such as nickel or cobalt, which were active in the high temperature region only, with the result that methane instead of liquid hydrocarbons were obtained. Fischer found that the temperature range for the liquid synthesis depended not only upon the catalysts used, but on the composition of the raw gases. The processing of high hydrogen content gases necessitated work at low temperatures and vice versa.

It was found to be more advantageous to conduct the operations at higher temperatures when using an iron catalyst than was the case with cobalt. The latter catalyst gave the following reaction:

$$CO + 2H_2 = (CH_2) + H_2O$$

For the iron catalyst the reaction was:

$$2CO + H_2 = (CH_2) + CO_2$$

The conversion of carbon dioxide into liquid hydrocarbons was possible, but did not take place smoothly or directly. It was more advantageous to reduce the carbon dioxide to carbon monoxide and water with a copper catalyst. The carbon monoxide formed was reacted with more hydrogen and cobalt at low pressures to form the desired gasoline hydrocarbons. To the latter products Fischer gave the name "kogasin."

The catalysts found to be the most suitable were the metals iron, cobalt, and nickel, which had the common property of forming carbides. The function of the kogasin catalysts was found to be the intermediate formation and decomposition of carbides. The following equation illustrates the reaction with iron at 250 C:

$$H_2 + 2CO + Fe_2C + Fe_3C_2 + H_2 + CO_2 = Fe_3C + (CH_2) + CO_2$$

The reaction for cobalt and nickel at temperatures below 200 C was:

$$2H_2 + CO + Co_2C = Co_2C_2 + H_2 + H_2O = Co_3C + (CH_2) + H_2O$$

Flow processes. Original process. The first step in the original process described by Fischer was the production of water gas in the usual gas generator from coke and steam. Water gas was passed through scrubbers and then through purifiers where the hydrogen sulphide was removed. The gas was next passed through a vertical contact chamber in which the organic sulphur content was reduced to a minimum value by means of a suitable absorbing reagent. The gases next entered a second contact chamber where synthesis took place at carefully controlled temperatures, which were usually close to 190 C. The high heat of the reaction was removed from the contact chamber by means of cold circulating oil. The heat absorbed by the circulating oil formed steam by contacting with water in a specially designed chamber.

Exit gases from the contact chamber amounted to about 25 per cent by volume of the incoming raw gas measured at room temperature, which resulted in a contraction of about 75 per cent for complete conversion. A more complete reaction and formation of kogasin accompanied the greater contraction percentages and lower operating temperatures.

After a light alkali wash used to free the products from traces of organic acids, fractionation resulted in the usual commercial liquid fuels. Although theory and pilot plant operations indicated that a mixture of raw gases could be converted to 100 per cent of benzine, such full conversion was not feasible in full-scale operations.

Late developments. The development of an economic natural-gas-to-gasoline process by Hydrocarbon Research, Inc., has been reported recently by Keith as a result of pilot plant investigation[9]. The so-called "Carthage" plant employing the Hydrocol process will be erected at Brownsville, Texas, and is designed to process approximately 64,000,000 cu ft of natural gas daily.

The process projected by Keith involves the following claims and operations:

(1) The recovery of approximately 0.25 gal of natural gasoline and butane per M cu ft of feed gas.

(2) The separation of 40,000,000 cu ft of oxygen per day from the air.

(3) Production of a carbon monoxide and hydrogen mixture by the partial combustion of 64,000,000 cu ft of natural gas with oxygen.

(4) The conversion of the carbon monoxide-hydrogen mixture into gasoline and other synthetic products.

(5) The separation of gasoline and other products by fractionation and absorption.

(6) Removal of oxygenated compounds, polymerization of propylene and butylene, re-running, blending, etc.

(7) Manufacture and revivification of catalysts.

Cheap oxygen and direct burning of the natural gas have been of major importance in the new synthesis from natural gas. The process for producing oxygen involves compressing and liquefying air with subsequent separation of oxygen from the nitrogen by fractionation. Operating at a synthesis pressure of 150-250 psi eliminated compression of the synthesis gas, which is about twice the volume of the reactants.

Synthesis gas may be produced from natural gas and oxygen by the following reaction[10]:

$$CH_4 + \tfrac{1}{2}O_2 = CO + 2H_2$$

From the above equation, the theoretical amount of oxygen required is one-half the volume of methane. Desulphurized natural gas and oxygen are passed to a combustion chamber where the reaction is exothermic and the temperature is about 2100 F. Once the incoming materials are preheated sufficiently, the reaction supplies the heat necessary for continuous operation. The exit gas is cooled to 600 F in a suitable boiler where the plant steam requirements are generated.

The gas next flows into the synthesis reactor where liquid hydrocarbons are formed. The reaction is aided by a powdered catalyst in a fluidized state, which is maintained in a turbulent condition by aeration with the gas. Fluid-type catalysts have special significance[10]. The finely divided material presents greater surface, which is easily accessible. Hence, the reaction proceeds faster. Catalyst activity, however, has seldom been the limiting factor[9]. More often it has been stated to be the efficiency of removal of the heat of reaction. With sufficient removal of heat, the space time

Record payment

Sinclair Oil Corporation leased 2945 acres in Crockett County, Texas, at a University of Texas auction of mineral rights and paid a record bonus of $910,000 with an agreement that a well be drilled to 9500 ft beginning before June 15.

WEATHERFORD DRILL PIPE WIPER

(Patent No. 2,392,146)

BOTTOM SIDE UP

The all-purpose Weatherford Drill Pipe Wiper is so constructed that it OUT-LASTS . . . OUT-WIPES . . . and OUT-SERVES all others.

The *bowl shape* of the Weatherford DPW produces these remarkable results:

1. "Flow-over" fluids are caught and delivered back into the hole. This is made possible by the four DRAINAGE PORTS (illustrated in the photograph) which are opened to the desired size by removing a portion, or all, of the thin layer of rubber blocking off the large molded holes.

2. It lasts longer . . . The *wiping lip* cannot be "chewed up" against the rotary table bushings by the tool joints and by the drill pipe . . . because the *bowl* holds it away from the bushings *at all times.*

The solid rubber construction of the Weatherford DPW gives it the following additional advantages: (1) No metal to tear loose from rubber, and (2) the elimination of "sparking" hazards.

The Weatherford Drill Pipe Wiper is available in the following sizes and net prices for the 2⅜", 2⅞", 3½", 4½" or 5-9/16" pipe size.

17 in. (outside diameter) 11 lbs. $40.00

14 in. (outside diameter) 7 lbs. $38.00

Prices subject to change without notice. For terms and conditions of sale, see Catalog No. SCS-101, Spiral Centralizers and Reversible Scratchers. Oil resistant Drill Pipe Wipers are furnished on specification.

FULL GUARANTEE

Due to its construction and the materials used, every Weatherford Drill Pipe Wiper sold during 1947 carries this guarantee: If the WDPW does not prove superior to any you have ever used, return it to the dealer from which it was bought and you will be given new rubber or your money will be refunded. Every dealer selling the Weatherford Drill Pipe Wiper will be instructed to execute the terms of this guarantee.

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If the predictions of the petroleum industry's automotive scientists are correct, within a decade practically all motor fuels and motor lubricants—although made from petroleum—will be synthetics.

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yield of oil is thought to be potentially of great proportions. The temperature is controlled by water-cooled tubes within the reactor, with the production of large quantities of steam, making the plant as a whole practically self-sufficient in power requirements. In addition to close temperature control, the fluid catalyst technique permits the use of the catalyst itself as a medium of heat transfer. A continuous process is made possible by the withdrawal of part of the catalyst and replacement with fresh material. Whereas in the German operations utilizing granular catalysts, the space velocities in volumes of fresh feed per volume of catalyst ranged from 100 to 250, in the fluid-type operation with iron catalysts, space velocities varying from 2000 to 3000 are said to be feasible.

Properties of kogasin. The products of kogasin were found to be composed of aliphatic hydrocarbons (paraffins), and also of mono-olefins. The latter were concentrated heavily in the low-boiling fractions. Only traces of oxygenated hydrocarbons are present when the operations are conducted at atmospheric pressure.

Kogasin contained no lubricating oil, but valuable lubricants were prepared from the aliphatic material of higher boiling range. Average runs for the original process employing cobalt as a catalyst, and a mixed gas containing 29 per cent carbon monoxide and 58 per cent hydrogen, results in the following yields:

	B.P. (C)	Weight, per cent	Olefines, vol. per cent
1. Gas oil	Below 30	4	50
2. Benzine	30–200	62	30
3. Oil	Over 200	23	10
4. Paraffin from oil	M. P. 50	7	..
5. Hard wax from catalyst	70 to over 80	4	..

It was found that the motor fuel required only a light soda wash and could then be used directly without further conversion for motors of low compression ratio. In those cases where high anti-knock fuel was required the product was mixed with benzol or with 10-20 per cent of alcohol, or with both of the materials. The sensitivity of the fuel to small increments of tetraethyl lead resulted in the rapid rise of octane numbers to the values required.

The item designated as "oil" in the above table served as a valuable diesel motor fuel having excellent combustion and other characteristics in diesel engines.

Medium and high pressure synthesis. The medium-pressure synthesis[6] accelerated by Fischer and Pichler in 1936 gave an optimum yield of solid liquid hydrocarbons at pressures of 75 to 220 psi, and temperatures in the range of 400 F[8]. This, too, was a highly exothermic reaction of the order of 7000 Btu per lb of liquid produced.

The loss in catalyst activity found for the low pressure synthesis was decreased notably in the medium pressure process. In general, the increase of pressure affected the formation of the higher-boiling hydrocarbons. At 1500 psi and 383 F, 5.9 lb of paraffin wax and 3.0 lb of oil were obtained per M cu ft of gas.

Naphthene and isosyntheses. Two new syntheses[6] have been announced since the beginning of the war. These are the "naphthene synthesis" and the "isosynthesis." Although the details, apparently, have not been reported, the reactions have been directed toward the production of naphthene and aromatic hydrocarbons in the "naphthene synthesis," and toward the production of isoparaffins in the "isosynthesis." It is inferred that the gasoline fractions would have high octane numbers, the C_4— fraction containing 90 per cent of isobutane. Isobutane dehydrogenated to isobutene, and alkylation of the remaining isobutane with the isobutene resulted in a 100-octane aviation gasoline.

Synthesis of lubricants. As synthetic gasoline or kogasin contains appreciable quantities of unsaturated hydrocarbons, the latter low-boiling olefinic fractions were treated with aluminum chloride and condensed to viscous polymers[6]. As a second procedure, the gas oil fraction of much higher boiling point, but deficient in olefins, was first chlorinated and the chloro-products treated with activated aluminum metal until the material was free of chlorine. This indicated that polymerization was complete, and white viscous oils were obtained. In a third process kogasin was condensed with aromatics such as xylol using aluminum chloride.

The first two synthetic oils named had properties closely approaching those of naphthene-base petroleum lubricants. Hydrogenation of the synthetic hydrocarbons prepared from kogasin resulted in water-white oils possessing extremely great stability toward oxidation and other desirable properties.

Other products. The synthesis of high-melting wax using ruthenium catalysts at high pressures was reported in 1938[6]. The Fischer-Tropsch process also has a promising application to the synthesis of raw materials for detergents, edible fats, solvents, aldehydes, alcohols, and acids, as shown by the operations in Germany during the late war[8].

Synthesis from coke. In Europe, at least the carbonization of coal has resulted in a large excess of coke in storage. Hence, it has become important to convert the excess stocks of coke to kogasin[8].

In the production of definite raw gases from coke a mixture was produced in which the proportion of carbon monoxide to hydrogen was 1:2. Continuous gasification of coke with oxygen and steam was preferred where cheap oxygen was available.

Denig[2] estimates the cost of gasoline from bituminous coke at 24.4 cents per gal based on the older European designs.

Synthesis from coal. According to Fieldner[3] the coal reserves of the United States are:

	Billions of net tons
Anthracite	15
Low-volatile bituminous	52
High-volatile bituminous	1351
Subbituminous	818
Lignite	939
Total	3175

Originally, coal with good coking qualities was used in this process. Although the total reserves of coal might conceivably be considered, it is probable that the cheaper grades would be used first.

The I. G. Farbenindustrie developed a method for producing suitable carbon monoxide-hydrogen mixtures by burning Braunkohle, a superior species of peat, with steam and oxygen[9]. A preheated mixture of oxygen and steam was introduced at high velocity through tuyeres around the bottom periphery of a so-called "Winkler" generator. The gas mixture passed up through a grate suspending the Braunkohle, with attending temperatures of up to 2500 F in the generator. As a result, the hydrocarbons contained in the raw material were distilled and cracked, and most of the mass was converted into a mixture of carbon monoxide and hydrogen.

Pilot plant operations have shown the advantages, both in products and economically, of distillation and partial gasification of coking and non-coking coals with oxygen. In this manner, city gas was produced directly from coal and oxygen, which was a direct improvement over the older conventional and more expensive gas-oil process. It has been estimated that city gas in the eastern cities such as New York can be made from bituminous coal at a cost of less than the cost of natural gas at the wells in Texas, assumed to be 5 cents per M cu ft plus transportation costs by pipe line to the East[9].

Furthermore, it was estimated that one ton of 13,000 Btu per lb coal at the mine mouth would yield 20,000 cu ft of synthetic natural gas, and that the net thermal efficiency or the ratio of the heating value of the product to the heating value of the coal would be about 80 per cent[9].

It has been stated that 0.8 ton of coal is required by the older Fischer-Tropsch process to produce 1 bbl of gasoline[2]. Hence, the yield of gasoline per ton would be approximately 1.25 bbl. Based

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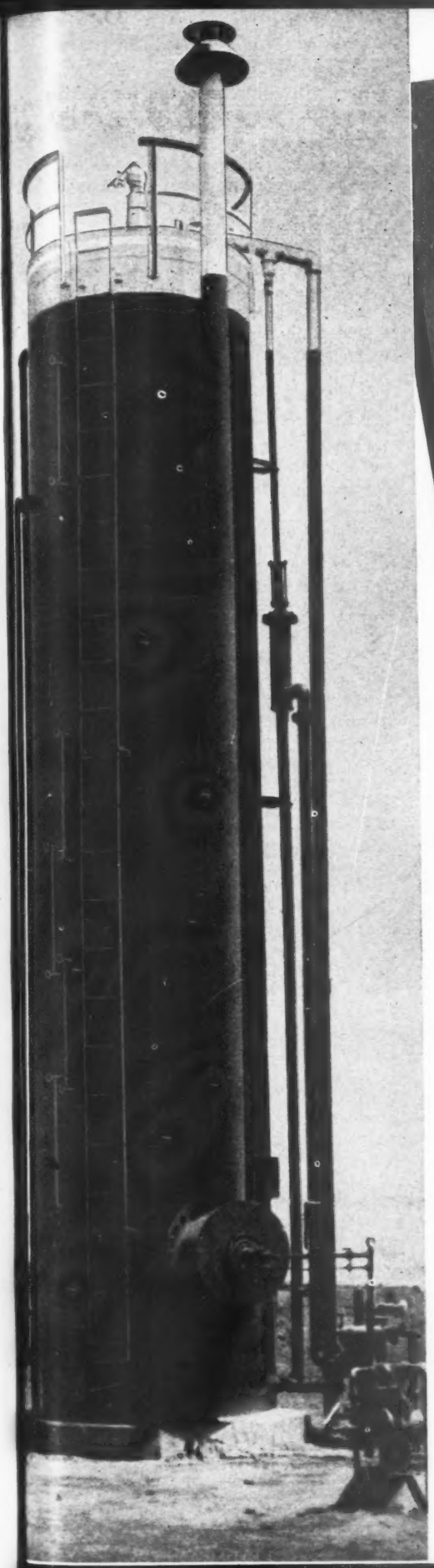
Petroleum refinery workers are the highest paid of 25 major U. S. industries including automobile industry.



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When desired, hot water recycling system preheats fluid in inlet line before it reaches the inside of the treater.

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Advanced design of heating elements provides more efficient use of fuel and transfer of heat to fluids and eliminates "hot spots" and excessive scale deposits.

Ample supply of hot salt water and baffles assure thorough washing and distribution of fluid.

Unusually large space above baffles to provide quiet space for water to settle out of oil.

Provision for cooling gas from hot oil before it passes into mist extractor and scrubber.

Design minimizes and controls any tendency of fluid to foam. In case of foaming oils, foam can be recirculated through heating compartment.

Removable baffles to facilitate cleaning or installing excelsior if desirable.

Adjustable oil settling height and salt water bath.

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on this minimum yield, the coal reserves of the United States would represent a potential liquid fuel reserve of some 4000 billion bbl; however, this reserve would be reduced to some 2000 billion bbl if coal most suited for the process were utilized.

It was also stated that only 8.3 per cent of the 1942 production of the U. S., or 48,000,000 tons of coal would be required for a 10 per cent boost in gasoline production[2]. The production of low-sulphur coals can be extended in both the Appalachian and western fields to meet the gradually increasing demand. All the 1940 gasoline demand could have been supplied through conversion of 180 per cent of the coal produced that year. Even at this rate of consumption our coal reserves have been estimated to last 1000 years.

Russell[2] has stated that a coking type of Fischer-Tropsch process would yield gasoline costing 19.2 cents per gal, which includes depreciation amounting to 4.5 cents per gal. The cost of bituminous coal would be $2.75 per ton. Denig[2] estimates the cost of gasoline from subbituminous coal at 18.2 cents per gal, based on the older European plant designs.

The estimated investment per barrel of motor gasoline for the present European plant designs has been placed at $7600[8].

The approaching coal-to-gasoline process[9], which is the combination of the direct gasification process and the Hydrocol process, is estimated to result in 6-cent gasoline from $2.00 per ton coal two or three years hence.

Synthesis from natural gas. DeGolyer[7] has estimated the proved gas reserves of the United States to be 144,289,552 million cu ft as of January 1, 1946. In recent years annual production has varied from 3 to 4 trillion cu ft. If a comparison is made on a Btu basis[2] the annual production of natural gas is about 40 per cent of crude oil production.

Published estimates[2] of costs of gasoline production by the Fischer-Tropsch synthesis show that natural gas costing 5 cents per M cu ft, and processed in plants of European design would amount to 8.8 cents per gal, including depreciation. The direct costs, including normal overhead, but excluding depreciation, are estimated to total 6.0 cents per gal.

Russell[2] has stated that for a production of 100,000 bbl of synthetic gasoline per day from natural gas, the investment was estimated to vary from $220,000,000 for a plant of future design, to $477,000,000 for a plant of European design. An investment cost of $4750 per bbl of motor gasoline per day[10] approaches the latter higher total figure.

Improvement in the Hydrocol process will, it has been stated[9], make possible the production of a barrel of oil from 8000 cu ft of gas. Furthermore, if the capital and operating cost of the Hydrocol plant is equal to that of an oil refinery, then 8000 cu ft of gas at the refinery will be equivalent to a barrel of 38-deg gravity Mid-Continent crude. Hence, gas at 17 cents per M cu ft would just balance crude oil at $1.35 per bbl.

The first experiment to replace coal with oil on naval vessels was made in 1864. The attempt being unsuccessful, the matter was dropped for 20 years. Now, all the world's navies use oil exclusively.

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From 64 million cu ft of natural gas the yield is estimated to be about 5800 bbl of motor fuel, 1200 bbl of synthetic diesel oil, and 150,000 lb of crude alcohols per day[9]. By mild refining, the raw gasoline shows octane numbers of about 75 80. Conversion of the carbon monoxide-hydrogen mixture of better than 90 per cent is obtained, and the yield of premium gasoline may amount to over 80 per cent of the total useful products[9].

The plant is estimated to cost $20.000,000 and will be placed in operation sometime in 1947. Crediting the diesel oil at 3½ cents per gal and the crude alcohols at ½ cent per lb, the "out-of-pocket" cost of the gasoline is predicted to be about 2½ cents per gal. Capital costs, including depreciation, amortization, and interest is expected to bring the cost of the gasoline to 5.25 cents per gal, which compares favorably with refinery figures at present crude oil prices[9].

It has been shown that the production of 1 bbl of gasoline by the older European process requires 11.950 cu ft (505 lb) of natural gas. On this basis it was estimated that if all the total known natural gas reserves were to be used for conversion a comparatively small synthetic gasoline reserve amounting to some 15 billion bbl would result. This reserve would probably be increased somewhat because of the increased yields of the latest American process[2].

Large natural gas requirements will be necessary for a synthetic plant[10]. For example, a 5000 bbl per day plant would require 50-70 million cu ft of natural gas per day. Over a 20-yr period this totals 365 to 510 billion cu ft. Plants situated near large gas fields may be advisable in some cases, although pipe lines may be built to suitable locations away from the sources of supply.

Some feel that our natural gas resources are inadequate to meet a petroleum or gasoline shortage. They believe that natural gas is too valuable as such to convert to petroleum by such a process as the Fischer-Tropsch. Others feel that natural gas constitutes the cheapest raw material for such a synthesis and might be conceived to be competitive with petroleum in the near future. The process is thought to have useful applications in particular where it can be combined with other processes, such as the production of natural gasoline and the manufacture of chemicals. Integration with the natural gasoline industry will afford an outlet for residue gas and for dry gas without a pipe line market.

Synthesis from other gases. As coke oven gas is deficient in carbon monoxide, it is advantageous to use carbon dioxide in its conversion, which brings the relation of carbon monoxide and hydrogen to the necessary 1:2 ratio.

Gasoline may also be synthesized from naturally occurring carbon dioxide obtained from gas wells. The carbon dioxide is reduced to carbon monoxide with copper catalysts and is further converted to benzine with electrolytic hydrogen using cobalt catalysts.

Comparative costs and economics. Estimates based on European designs as developed by Russell[2] indicate the following comparative costs using the Fischer-Tropsch process:

	Cost per gal gasoline (not incl. depreciation)
Using coal, at $2.25-2.35 per ton	$0.147
Using natural gas, at $0.05 per M cu ft	0.06
Modern oil refinery, crude at $1.29 per bbl	0.051
Modern oil refinery, crude at $2.00 per bbl	0.083

The investment cost estimated by Russell[2] would amount to about 5 cents per gal based on a carrying cost of the investment at 10 per cent annually. A large number of plants of 3000 tons converting capacity each were considered in this estimate. Savings in plant investment are likely by the use of large by-product coking plants approaching 33,000 tons of coal per day. Based on a coal cost of $2.35 per ton, and with low fixed charges and operating costs incident to plant size and high load factor, the cost of the coke supplied the water-gas conversion units and the cost of the water-gas into the Fischer-Tropsch synthesis could be reduced further. By-product coal gas, tars, and light oils could be processed and yield additional revenues.

General agreement exists that gasoline from dry natural gas is cheaper to produce than is gasoline from coal. As an example, with natural gas at 5 cents per M cu ft, the cost of gasoline using 10,450 cu ft of gas per bbl, would be approximately $0.52. It would be necessary for the price of coal to be about $0.77 per ton, if it is assumed that 1360 lb of coal are required per bbl of gasoline produced, in order for the costs of the two processes to compare favorably[8].

Other estimates show the following comparative costs for producing synthetic fuels[10]:

	Investment cost per bbl per day	Cost per gal including 10 per cent depreciation, cents
European process using coal	$7600	19.2*
European process using natural gas	4750	8.8**
American process using natural gas	2000-2500	5.0**

*Coal at $2.75 per ton.
**Natural gas at 5 cents per M cu ft.

As mentioned previously, 5.25-cent gasoline is anticipated from the new Hydrocol plant using natural gas, and

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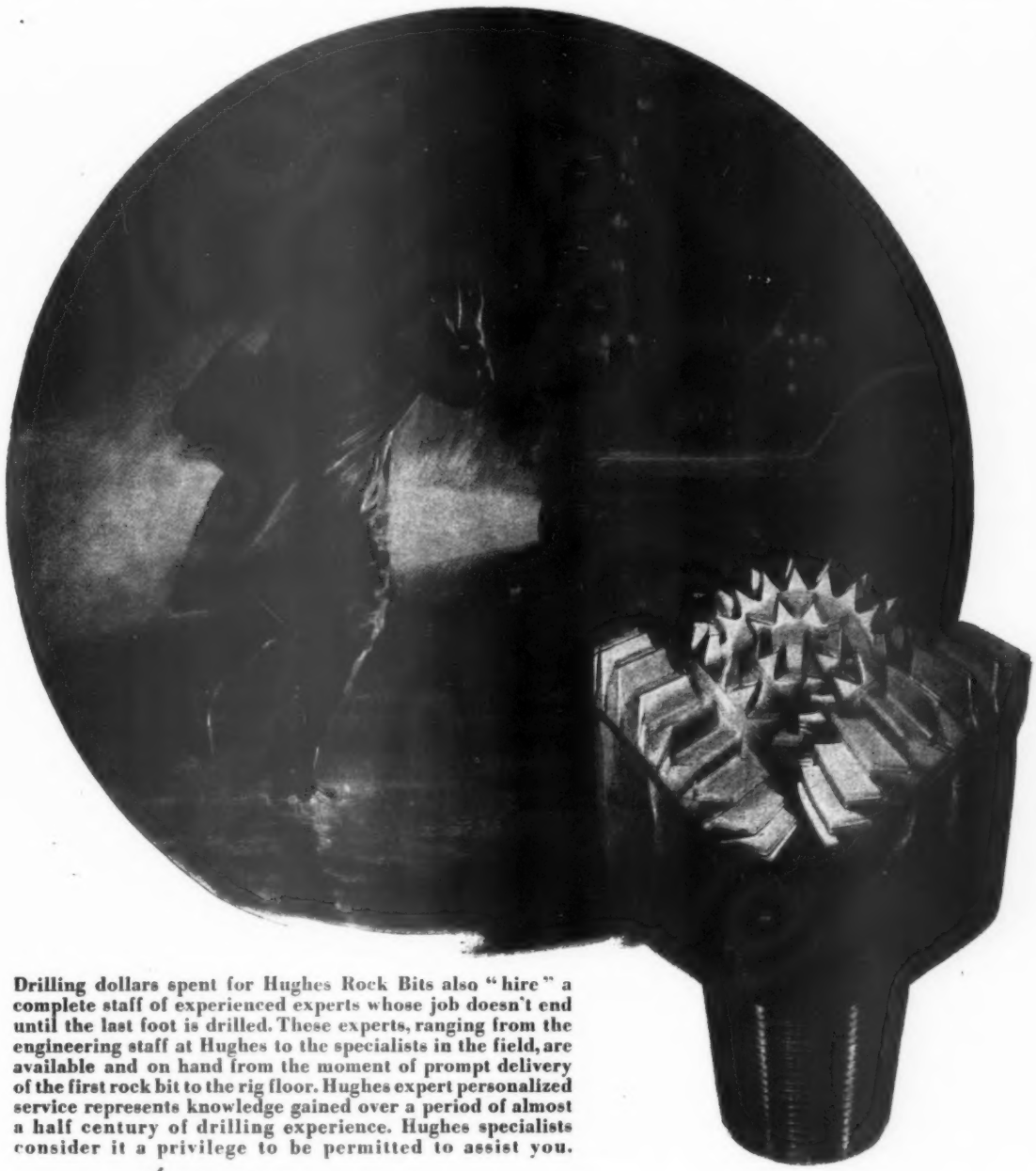

Drilling dollars spent for Hughes Rock Bits also "hire" a complete staff of experienced experts whose job doesn't end until the last foot is drilled. These experts, ranging from the engineering staff at Hughes to the specialists in the field, are available and on hand from the moment of prompt delivery of the first rock bit to the rig floor. Hughes expert personalized service represents knowledge gained over a period of almost a half century of drilling experience. Hughes specialists consider it a privilege to be permitted to assist you.

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Polystyrene, which can be made in part or entirely from petroleum sources, is one of the most widely used lightweight resins for plastic manufacture. Transparent, it is used in place of glass for clock and instrument faces, and in many similar instances.

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the approaching coal-to-gasoline process, a combination of the direct gasification process and the Hydrocol process, may result in 6-cent gasoline from $2.00 coal two or three years hence[9].

Cost factors are inherent in the use of coal that act to reduce the above differential between Fischer-Tropsch gasoline and gasoline at the modern refinery. One of these factors is transportation cost. Crude oil from west of the Mississippi comes a long distance to Eastern markets. The synthetic plants at the mines would be close to the area of consumption, and freight cost on gasoline cut accordingly.

The available data from the literature as presented hereinbefore is summarized in Table 1 on Page 72.

Considering the various sources of raw materials, it is evident that the high cost of coal hydrogenation will bar the process from immediate consideration. Although the investment costs per barrel per day for coal carbonization do not appear to be too large, yet the cost per barrel of gasoline as reported is still out of line with other processes. In addition, the immense quantities of coke, unless converted to other products, present a handicap to this operation. Although the presently known investment and operating costs for shale-oil operations are high, full-scale government operations impending will help to clarify their economic significance. The estimated reserves of shale oil in this country alone are of sufficient extent to be reassuring in a future emergency. Further development of tar sands, particularly from the standpoint of full-scale operations, should throw more light on their competitive importance, especially at distances away from such deposits, but closer to crude oil sources of supply. Locally, tar sands appear to be competitive with local sources of gasoline from petroleum, especially in Alberta.

The efficiency of the Fischer-Tropsch synthesis, implied from the yield of gasoline, is low, for only about 40 per cent of the heat content of the gas charged to the process has been recovered in the liquid product. Conversion of coal is said to be less efficient than the conversion of natural gas. Further research, however, will continue to improve these efficiencies materially[2], with large-scale synthesis from coal economically possible, after the preliminary full-scale pioneering with natural gas will have been demonstrated fully.

Williams[24] states that gas in the eastern industrial area is now worth about 25 cents per M cu ft when compared with coal on the basis of its heating value. The conversion of coal to methane and ethane is a factor that will also influence the value of natural gas. Recent developments in the United States indicate that synthetic natural gas having a heat content of approximately M Btu per cu ft may be expected. It is estimated that such gas can be produced from coal at a cost of from 16 to 20 cents per M cu ft. Inasmuch as the coal mines are near the eastern industrial centers, it is seen that the transportation of gas from Texas will not justify a very high price at the wells. Williams does not consider it likely that the value of gas in South Texas will be in excess of 8 cents per M cu ft although the economics of the Fischer-Tropsch synthesis indicate that natural gas may be worth from 8 to 12 cents for the manufacture of liquid fuels. The price of synthetic gasoline and liquid fuel, in turn, will not only depend on the usual supply and demand, but on the supplies and prices of crude oil products at home and abroad. The transportation of natural gas to outside areas such as the utilization of residue or oil well gas by the El Paso Natural Gas Company in connection with its Texas-California gas pipe line[25], will have its influence on future availability and price of Texas gas. In addition, one must not lose sight of the role of natural gas in pressure maintenance and repressuring. Many believe this to be the primary use for gas whereby increased ultimate oil production may be obtained.

Modifications of the Fischer-Tropsch synthesis from natural gas will find interesting applications, particularly where it can be combined with other processes or with existing facilities. For instance, the production of natural gasoline and the manufacture of chemicals present one opportunity for such a combination. The success of the development brings new problems of integration with the natural gasoline industry. It affords an outlet for residue gas and for dry gas without a pipe line market. Furthermore, it promises to compete with the natural gas fuel industry for this gas. As higher price markets for natural gas are developed the present low price market will disappear. Hence, it is believed that our natural gas resources will not be exhausted prior to those of crude oil[20].

If, as Oberfell has stated, we doubled the efficiencies of oil recovery, doubled the yield of motor fuel from crude oil, and doubled the efficiency of utilizing the fuel in the engine, one barrel of oil reserves could be made to last as long as eight do at the present time. Hence, our present known reserves of oil would last 100 years instead of the present estimated 15 to 20 years. More chances appear for research to develop new sources of energy or to make the energy available in present fuels more efficient. A surplus of crude oil might exist under these conditions rather than the prospect that our petroleum resources will be exhausted in less than a century[20].

It is essential that government and other research programs concerned with petroleum should be expanded, for the life and amount of our petroleum reserves will be extended accordingly. The present research on our auxiliary sources of supply is a complementary and necessary program. It is quite possible that research on the conversion of coal and natural gas and other source materials will have a primary application and benefit to the petroleum and natural gas industries in that the latter, because of this research, will be enabled to manufacture more and better fuels and lubricants[20].

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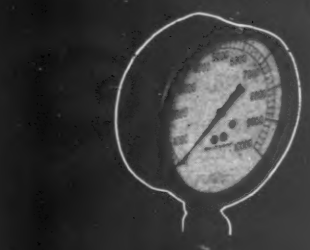

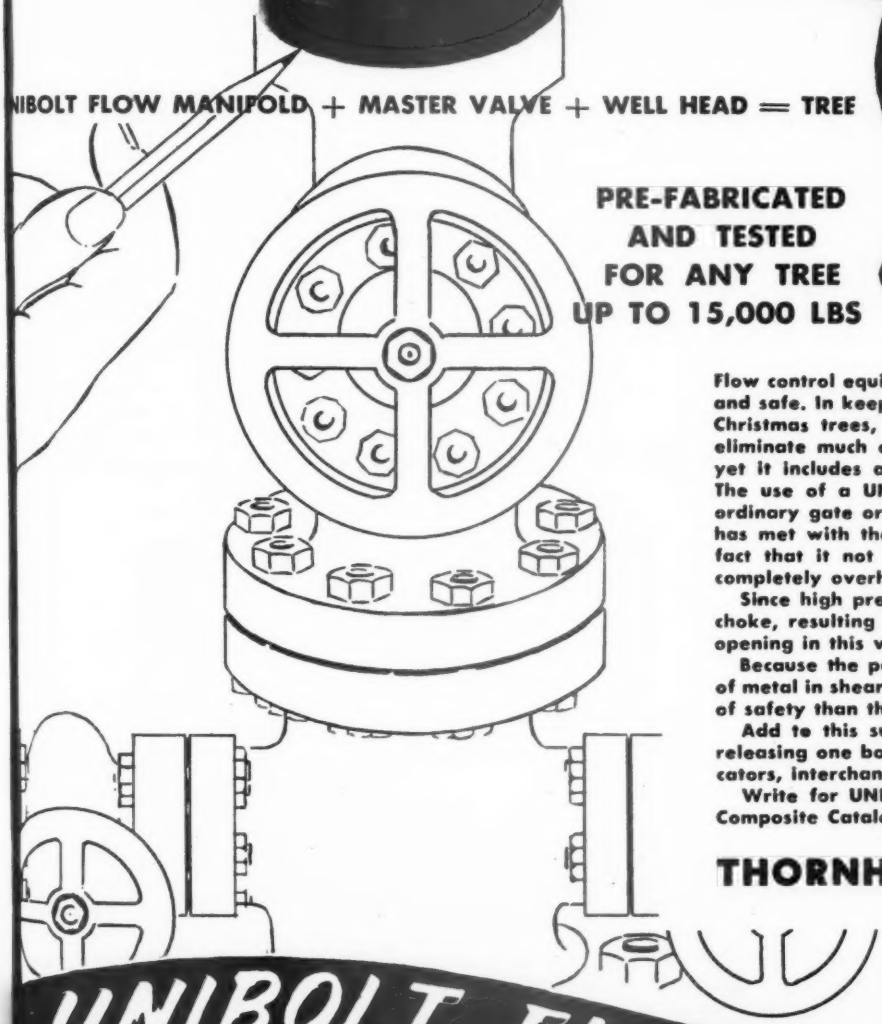

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UNIBOLT FLOW MANIFOLDS

Fuels used in Sweden

By **GUSTAV EGLOFF,** Universal Oil Products Company

As a member of the Scandinavian Research and Industry Tour under the directorship of Dr. Edy Velander of the Royal Academy of Engineering Sciences by invitation of the Swedish government, the writer had an excellent opportunity of studying the fuel resources of Sweden.

Sweden is dependent upon foreign countries for both its petroleum and its coal. Petroleum has not been discovered anywhere in the country, although some drilling has been done in the Skanor district, and although Sweden mines some coal, the amount produced is quite insufficient to meet its industrial needs. For centuries prior to the Industrial Revolution, Sweden's forests provided an adequate fuel supply, but with increasing need for power in the industrial era its native wood had to be supplemented in ever increasing quantities by cheaper fuels of higher heating value. During World War II, with almost a complete western blockade in 1940, Sweden was thrown back upon its natural resources, which consisted of wood, peat bogs, coal, and oil shale deposits. By expanding the uses of these basic fuel sources and maintaining a rigid economy in the use of fuels for domestic heating, industrial power, and transportation, Sweden has been able to maintain its economy in excellent condition, although with the end of hostilities and the lifting of the blockade it is rapidly returning to its use of imported fuels.

Sweden's prewar imports of petroleum were principally from the United States with a small amount from Venezuela. Its coal came primarily from England. Imports of petroleum and coal supplied 70 per cent of its fuel needs. It has not yet been possible to resume coal imports because of the marked shortage of coal in England at the present time. England is rapidly converting to an oil economy in place of one based on coal.

In 1939, at the outbreak of the European conflict, Sweden was importing 8,000,000 metric tons of coal and coke, the bulk of which came from England. In 1940, these imports had dropped to 5,700,000 metric tons and in 1942, the estimated imports were of the order of 3,000,000 tons. As part of the general economy measures the industrial consumption of coal was reduced to a rate of 600,000 tons a year in 1942. The consumption of coal in the iron industry was reduced to one-third of its prewar tonnage. Sweden's domestic production of coal is about 430,000 tons, which obviously was totally inadequate to meet her needs for coal and coke. Her present economy with poor prospects of further supplies of foreign coal must therefore be maintained without this source of fuel. Some coal is being imported from Poland at the present time (September 1, 1946). Sweden is turning toward an oil economy instead of one based on coal and wood.

Up to April 9, 1940, Sweden was able to maintain her imports of petroleum products at normal prewar levels. Sweden's imports of mineral oils from 1937 through 1945 are given in the following table.

Imports of mineral oils, 1937-45:

Year—	Bbl.
1937	8,820,000
1938	9,930,000
1939	11,070,000
1940	4,010,000
1941	984,000
1942	788,000
1943	1,094,000
1944	1,020,000
1945	1,440,000

After April, 1940, only a trickle of liquid fuel was allowed into Sweden by the belligerent countries. The lack of liquid fuel was offset by radical cuts in fuel consumption and the substitution of ordinary fuels by home products from wood, shale, and peat.

Wood cutting was increased rapidly during the war-years as is shown by the following table.

For year ending July 1,	Wood production, cu. m.
1940	20,000,000
1941	35,000,000
1942	45,000,000
1943	55,000,000

Most of Sweden's forests are privately owned and the increased volume of wood was brought about by a combination of voluntary cutting and compulsory regulations. The increased volume of wood was used for a great variety of purposes. Primarily it was employed as fuel in industrial plants, by railroads, and for heating of buildings of all sizes. It was also consumed in the manufacture of wood pulp, paper, alcohols, chemical products, and rayon. It supplied charcoal both for metallurgical purposes and for the generation of producer gas for automotive vehicles, a large percentage of the latter using wood directly. Locomotives burned wood and many of these are still using wood as fuel.

Compressed straw was also used as a fuel. In the wood pulp and paper industry alone, the use of over 500,000 cu. m. of straw as fuel conserved more than 50,000 tons of coal. It is reported that compressed straw was four times as expensive as coal, and wood twice as expensive, whereas fuel oil was 25 per cent cheaper in August, 1946.

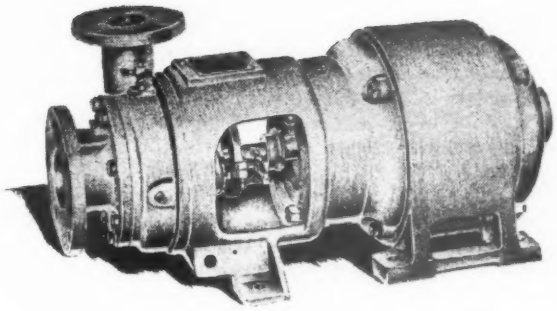
Beset with gasoline shortages along with the rest of Europe, Sweden resorted early to the use of producer gas driven vehicles. Here she was able to supply both wood and charcoal as fuel for the gas generators. Wood was used not only in block form but in the form of chips. To provide charcoal for use in both metallurgical operations and producer gas generators on motor vehicles, about 3000 furnaces producing charcoal were operating in 1944. Although charcoal is more compact and convenient for the operation of producer gas generators, twice as much wood is required and its use increased so rapidly that alarm was felt over the rapidly dwindling wood resources of Sweden. By 1942, producer gas driven automobiles required 8,000,000 cu. m. of wood annually, an amount greater than all the wood fuel marketed before the war.

Prior to the war, from December, 1935, to December, 1939, privately owned cars increased from 109,096 to 180,717, buses increased from 3,914 to 5,109, and commercial vehicles from 41,803 to 63,028. The 1939 total of motor vehicles was thus 248,902. The nation's economy was becoming rapidly geared to motor transport and when gasoline supplies dwindled, rapid conversion to producer gas was necessary. At the beginning of 1942, the total number of road vehicles still operating was 79,526. The number operating on producer gas was 72,755, which included 29,944 passenger cars, 39,147 commercial vehicles, and 3,664 buses. At this time 40 per cent of these vehicles used wood and the remainder charcoal, but already restrictions on the latter fuel were beginning to be felt because of the need of charcoal for steel plants. At the end of 1943, the total number of motor vehicles operating in Sweden was 77,755 of which 70,780 were operating on producer gas, the remainder using gasoline or substitute liquid fuels. Farm tractors were operated almost entirely on wood. Of the country's 20,000 tractors more than 4,000 had been converted for producer gas by the end of 1941. Some continued to use imported gasoline and that produced from oil shale. A number of Army vehicles were converted to the use of producer gas although most of them were operated on gasoline.

In 1942, the demands of producer gas engines required 2,500,000 cu. m. (88,000,000 cu. ft.) of charcoal and 2,000,000 cu. m. (71,000,000 cu. ft.) of wood. Dried peat was used to some extent in the gas generators for motor vehicles.

Swedish engineers showed a high degree of mechanical skill in the adaptation of their motor driven vehicles to the use of producer gas. Four hundred designs of generators were submitted to the State Commission for approval.

Other products from wood that were



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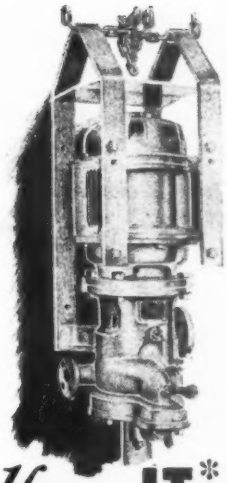

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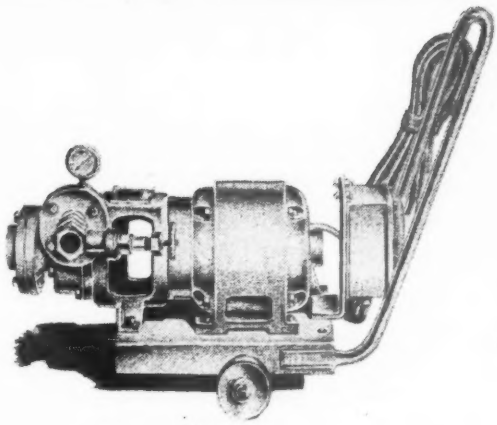

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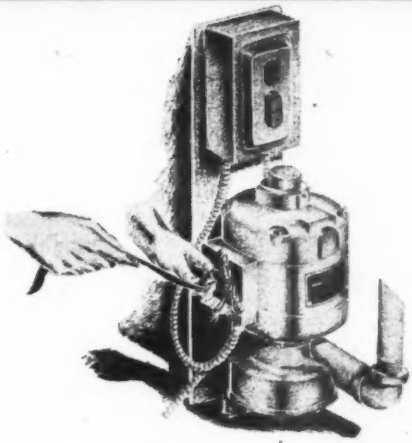

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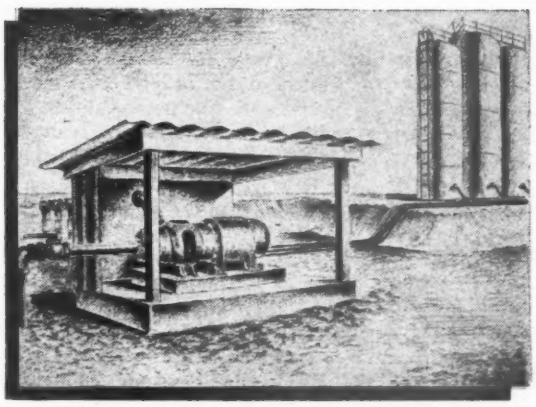

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utilized to supply the motor fuel deficiency during the war were ethyl alcohol made from the fermentation of sulphite liquor, and methyl alcohol and wood tar obtained from wood distillation. The normal prewar production of alcohol in Sweden was about 26,000 metric tons of which 18,000 was used in motor fuel. At this time the alcohol production was used in the national drink (Aquavit), as motor fuel, and as a source of ethylene for chemical manufacture. By 1942, the output of alcohol in Sweden had more than doubled, and by 1945 was three times the prewar output. In July, 1942, the Swedish Board of Fuels was forced to release a portion of gasoline in storage for use in such services as ambulances, fire engines, and police cars, where speed was necessary. The board decreed, however, that engines in vehicles used for these services should use two standardized fuels, one containing 50 per cent alcohol and the other 85 per cent, the rest being gasoline. Proposals were made to use unblended alcohol but it was found to affect engines adversely because of the presence of acetic acid. Since the end of the war in the transition period, a fuel consisting of 25 per cent alcohol and 75 per cent domestic shale oil was sold at about 85 cents a gal. but this offered little inducement to consumers who preferred to await the resumption of gasoline marketing at about 30 cents a gal. At the present time (August, 1946), 15 per cent of alcohol must still be blended with gasoline.

Tar oils from wood carbonization were utilized both as heavy engine fuels and as lubricants. Tar best suited for engine fuel was that obtained from pine wood and its principal use was in farm tractors and fishing boat engines. In some cases the tar oil was used in admixture with alcohols to decrease viscosity.

Another domestic source of fuel that was stepped up in production was the centrally located deposits of peat. The production of this fuel was but 25,000 tons annually at the beginning of the war but rose to 700,000 tons annually by 1942. This production corresponded in fuel value to about 350,000 tons of coal, a not inconsiderable quantity. A government corporation was formed to manufacture peat briquets and stimulate production from state owned properties. Peat was also used as a powder and peat coke was available for many purposes. The production of peat served particularly to supplement fuels for domestic heating.

Sweden has large shale deposits at Kinnekleva (Vastergotland) and Kvarntorp (Narke). The yields of oil from the shale in these deposits are from 5 to 6 per cent but the total resources are large. At the first locality, the deposits are estimated to contain 175,000,000 bbl. of oil. Distillation of the crushed shale was conducted in batteries of Bergh stills to produce gas at the rate of 40 to 45 cu. m. per ton and asphaltic base oil, which was brownish-green in appearance, had a specific gravity of 0.97, and Saybolt viscosity of 96 seconds at 68°F. The crude oil contained 15 per cent gasoline with a specific gravity of 0.662. Among the by-products were a high-grade sulphur, and in the spent shale were aluminum, vanadium, molybdenum, uranium oxides, and radioactive material. The oil shale plant built at Kinnekleva by the government cost about 10,000,000 kroner, or, on a United States exchange basis $2,500,000. It is now shut down.

The Narke deposits located at Kvarntorp, having a higher oil content than the shales of Kinnekleva, are estimated to contain from 350,000,000 to 420,000,000 bbl. of oil. During the war the capacity of the shale oil refinery at Kvarntorp was increased from a production of 200,000 to 500,000 bbl. of oil per year. It is planned to enlarge the capacity of the Kvarntorp plants to 800,000 bbl. by improving the productivity of the oil shale retorts. This will proportionally increase the amounts of the main and by-products. The new shale oil plant constructed at Kvarntorp in 1942 cost roughly 80,000,000 kroner or 20,000,000 United States dollars.

Four processes are in use in the recovery of oil from shale. These are the Bergh, Rockesholm, modified Estonian, and the Ljungström processes. One of the most interesting phases of the Swedish shale oil development has been the application of the Ljungström electro thermic process. In this method, electrical resistance elements are inserted on the corners of a hexagon in 50 ft. of shale itself and oil is distilled into a vapor line as a central core. At the production capacity of 1946, the Kvarntorp refinery produces annually 225,000 bbl. of gasoline, 32,000 bbl. of kerosine, and 325,000 bbl. of fuel oils. The gases contain about 20 per cent hydrogen sulphide from which 22,000 tons of high quality sulphur is obtained. The residual spent shale from the oil shale distillation is used as fuel in boiler plants, which are for the generation of electricity. Waste heat boilers are also used, and their output is converted to electrical energy. Production of chemical derivatives from the hydrocarbons of lower molecular weight and liquefaction of propane and butanes are also contemplated, as well as the manufacture of bricks, ceramics, and insulating "wool" from the spent shale.

Minor motor fuel sources utilized during the war included methane, acetylene, illuminating gas, and benzol. The Stockholm city sewage plant produced methane gas in an amount equivalent to about 500 gal. of gasoline daily. This gas was used in the engines of buses and motor vehicles in the city of Stockholm. On May 1, 1941, there were 686 vehicles in Sweden propelled by acetylene, methane, or illumating gas. Eighty-eight vehicles were electrically driven. There were 143 motorcycles with producer gas units and one running on electrical power. A small amount of benzol recovered as a by-product of coal carbonization was used but since the amount is dependent to a large extent upon coal imports, this use is not likely to increase.

Sweden is now rapidly converting to a postwar economy. Her fuel requirements are increasingly being met by imports of petroleum and petroleum products, for the prospects of increased imports of coal are poor. In fact, coal seems to be scarcer at the present time than during the war and it is felt that prices will remain high for a long time. Many Swedish industries are making provision for changing from wood and coal to fuel oil, particularly cement works, pulp mills, and power stations and it is felt that many other industries will also adopt oil fuel. Sweden consumed only 1,500,000 bbl. of fuel oil in domestic heating and in industry before the war. It is now estimated that 3,225,000 bbl. were consumed in 1946. The Swedish government is aiding in the conversion to oil by providing equipment priorities.

Prewar Sweden imported a major portion of its petroleum as refined products; however, the A. Johnson and Company, with a marketing company called Nynas Petroleum, had a refinery in operation near Stockholm with a present charging capacity of 12,000 bbl. of crude per day. During the war this refinery operated on shale oil, wood tars, and redistillation of oil products. It also produced a number of different chemical products. As crude oil has become available again it is resuming capacity operation.

A. Johnson and Company also have a refinery at Malmo with a capacity of about 3000 bbl. a day of crude oil. A large scale new refinery is being built in Gothenburg.

In December, 1945, Sweden's imports of gasoline were 305,000 bbl. and its imports of fuel oil were 367,500 bbl. The octane rating of unleaded gasoline now being sold in Sweden is from 70 to 72. The Nynas Petroleum Company is the first to market a tetraethyl lead gasoline in Sweden. The octane rating of the new gasoline is 80, and it is being marketed at no increase in price over the 70 to 72 octane number gasolines.

Sweden today is alive to the advantages of using petroleum products and undoubtedly will head toward a resumption of petroleum imports greater in volume than those of the prewar years. Crude petroleum will be needed for the operation of the present and contemplated refineries and refined products including gasoline, kerosine, furnace oil, and fuel oil will be required to supplement the products of home refining. Increasing use of petroleum will occur in industry in the heating of homes and buildings and as fuel in motor driven vehicles, railroads, and shipping. ★★★

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The world's total proved crude-oil reserves today — approximately 60 billion barrels — are larger than all the petroleum that has been produced during the entire history of the industry, going back 88 years to 1859.

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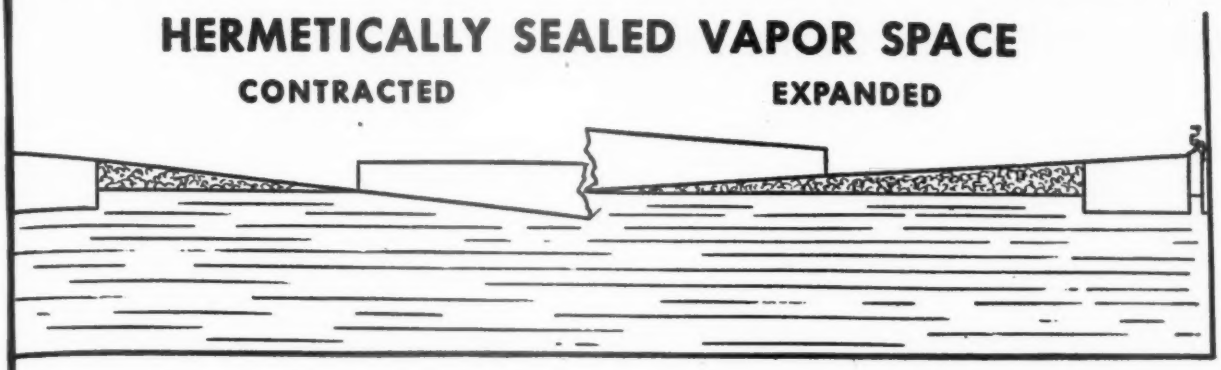

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Hydraulic drives in the oil fields*

By **NICHOLAS A. D'ARCY, JR.,** Charles W. Carter Company

HYDRAULIC drives can be classified into three general groups, as used in the oil industry today. Hydraulic couplings are used essentially where the output of speed and torque requirements are fairly uniform and the prime mover generally operates at a uniform speed or against the governor. Hydraulic torque converters are used where the speed and torque requirements vary and generally where the prime mover is operated by the throttle. Positive displacement fluid pumps and motors are generally used in relatively small horsepower installations to eliminate complicated shafting and drives. The positive displacement fluid pumps and motors fall into the classification known as "hydro-static drives" and the torque converters and hydraulic couplings into the classification known as "hydro-kinetic drives."

Hydraulic drives have been used successfully in every phase of the oil industry, from geophysical drill rigs to refinery operations, and new uses are constantly being developed for the proper hydraulic installations. It is essential that a thorough engineering analysis be made of each contemplated hydraulic installation in order to insure proper performance.

● **Basic principles of hydro-kinetic drives.** Both the hydraulic torque converter and the hydraulic coupling are closed circuit hydraulic units consisting of a pump or impeller on the driving end and a reaction member on the driven end. The rotation of the impeller imparts kinetic energy to the fluid in the closed circuit and drives the fluid to the outer periphery of the unit. The turbine member then absorbs the kinetic energy of the fluid in its blades and the fluid, having lost its velocity, is returned to the central portion of the unit. The impeller again picks up the fluid and the cycle is repeated. There is no mysterious characteristic imparted to the fluid at high velocities, as has sometimes been described. The entire action is based on well-known laws of hydraulics.

There is no positive connection between the impeller and the turbine member, and this feature allows the fluid to absorb vibration, and provide smooth starting. Both torque converter and coupling depend upon the kinetic energy imparted to the fluid for their drive. Both units transmit horsepower in proportion to the cube of the speed of the driving member and the 50 power of the diameter. Both units develop torque in proportion to the square of the speed of the driven member and the fifth power of the diameter.

● **Characteristics of hydraulic couplings.** The hydraulic couplings used in the oil industry fall into two general classifications, the traction or filled type coupling and the scoop tube coupling. The filled coupling is the simplest and most inexpensive unit and it dissipates any heat developed through slippage by radiation to the air through the skin of the coupling. This limited ability to dissipate heat ordinarily will confine the coupling to those installations where there is less than 10 per cent slip. The scoop tube coupling has two additional features. The fluid in the coupling is constantly circulated through an exterior heat exchanger or cooler and, when the cooler is of sufficient capacity, the scoop tube coupling can be run for long periods of time at any desired slippage up to and including 100 per cent. Manipulation of the scoop tube also regulates the amount of fluid in the coupling and this in turn will regulate the amount of slip obtained for any given input speed and output load.

Every hydraulic coupling, regardless of size or type, transmits the torque of the prime mover in a 1 to 1 ratio, there being no multiplication or loss of torque through the unit. The efficient operating range of all couplings is when the input speed and the output load requirements are such that there is not over 3 to 4 per cent slip in the coupling. From this you can see that the hydraulic coupling will give similar operating characteristics to a direct drive, but the coupling will absorb shock loads and facilitate starting of heavy loads under conditions that would be difficult with the direct drive. Hydraulic couplings applied to internal-combustion engines normally

*Presented before American Institute of Mining and Metallurgical Engineers, Petroleum Division, Los Angeles, California, October 24 and 25, 1946.

FIG. 1

COMPARISON POLISH ROD LOAD WITH FRICTION CLUTCH & HYDRAULIC CLUTCH

TOTAL DEPTH 7674' STROKE 66
PUMP AT 5680 S P M 1968 - FRICTION
RODS 2990 $\frac{7}{8}$" S P M 1934 - HYDRAULIC
2690 1"
PUMP 3 × 2$\frac{1}{4}$ × 15 COUNTERBALANCE - AIR
AIR PRESSURE - 140-165

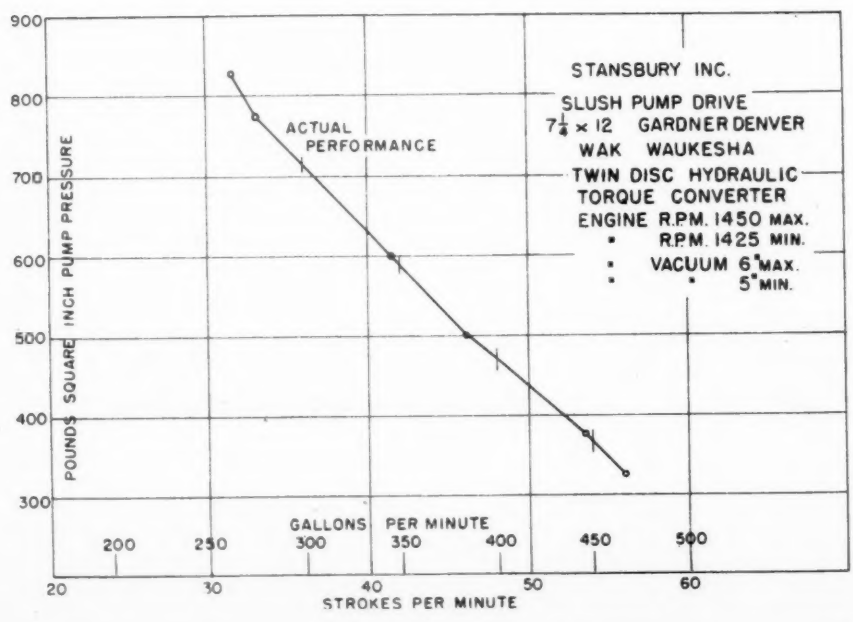
POLISH ROD LOAD	HYDRAULIC H.P. 18
MAXIMUM 26,150	POLISH ROD H.P. 32.6
MINIMUM 9,730	33,400 LBS / SQ IN.
DIFFERENTIAL 16,420	IN 1" RODS

FRICTION CLUTCH

POLISH ROD LOAD	HYDRAULIC H P 18
MAXIMUM 24,350	POLISH ROD H.P. 27.6
MINIMUM 11,330	31,200 LBS / SQ IN
DIFFERENTIAL 13,020	IN 1" RODS

HYDRAULIC CLUTCH

FIG. 2



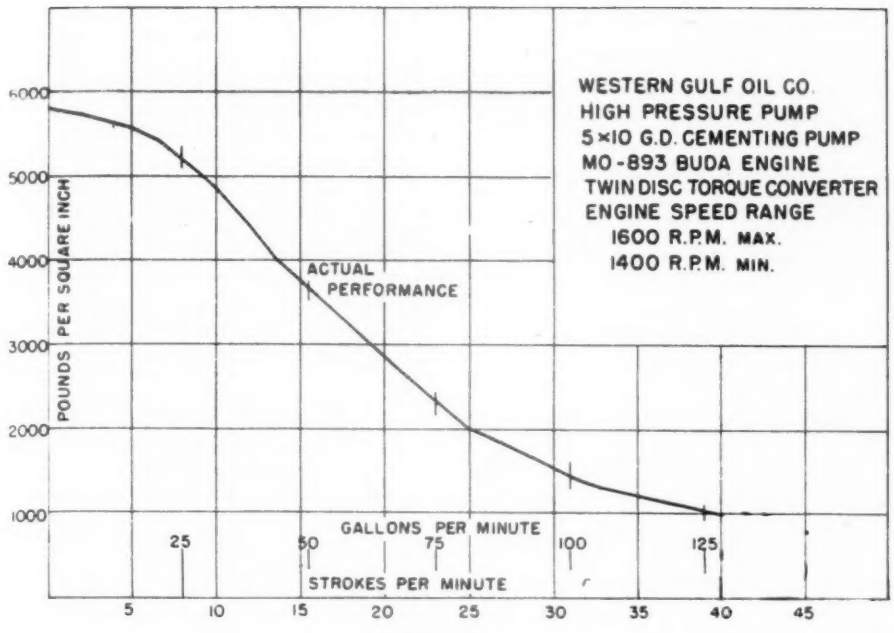


FIG. 3

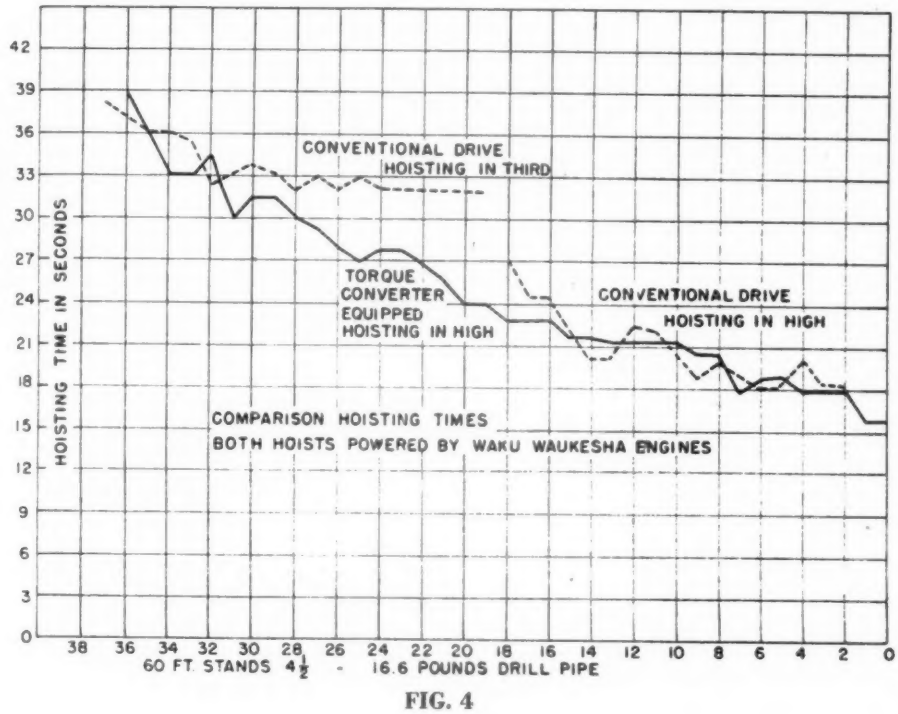


FIG. 4

transmit the full torque of the engine at approximately 40 per cent of the rated speed of the engine. The coupling will generally approach 10 per cent slip when transmitting full torque of the engine at approximately 60 per cent engine speed and will have between 5 and 3 per cent slip when operating at between 90 and 100 per cent of rated engine speed. These slips and speeds are based upon the assumption that the full torque of the prime mover will be required in driving the particular unit in question. From this you can see that the internal-combustion engine will normally reach approximately 40 per cent of its recommended operating speed before the coupling tends to load the engine. This greatly reduces lugging and also prevents killing the engine under adverse operating conditions.

Electric motors have torque characteristics radically different from internal-combustion engines. They will develop approximately 2 to 4 times their normal full load torque at approximately 70 per cent of their synchronous speed. Hydraulic couplings installed on electric motors will allow the electric motor to reach approximately 70 per cent of its synchronous speed before the coupling tends to load the motor. Between 70 and 100 per cent synchronous speed, the hydraulic coupling will be absorbing full torque of the motor, and when the coupling is properly balanced to a given motor, there will be between 3 and 5 per cent slip at the motor's recommended full load torque and speed. The hydraulic coupling cannot be used as an over-load limiting device in connection with high torque electric motors, as the coupling will transmit from 2 to 3 times the rated full load torque before the coupling reaches the stalled torque point. Couplings do, however, limit the shock load imposed upon a piece of machinery and, in reducing the shock load, they do materially reduce the number of failures occurring in those drives where a sudden build-up is apt to occur due to jamming a particular mechanism.

● **Applications of hydraulic couplings.** The most widespread application of hydraulic couplings in the oil industry has been in connection with slush pump drives. In order to utilize satisfactorily a hydraulic coupling in connection with the slush pump, provisions must be made for cooling the fluid in periods of excessive slip. For this reason, the scoop tube coupling is employed. The installation of a suitable hydraulic coupling allows the operator to maintain an efficient engine speed regardless of the speed of the slush pump. On surface hole the engine will operate at its most efficient speed and the coupling will transmit the power with between 3 and 5 per cent slip, producing the maximum desired slush pump speed. As the hole deepens, either the circulating pressure will be increased or the volume must be decreased. The engine speed can be maintained constant with the hydraulic coupling in the drive. The hydraulic coupling transmits engine torque at a 1 to 1 ratio, therefore the slush pump pressure remains constant. There will, however, be decreased circulating volume and slower operation of the slush pump because of an increased slippage in the coupling resulting in a greater loss of power. Manipulation of the scoop tube regulates the amount of fluid in the coupling which, in turn, controls the output speed of the coupling for any given torque requirements. The operator can maintain a given stalled pressure in his slush pump for any desired period of time when a scoop tube hydraulic coupling is included in the drive.

Traction or filled hydraulic couplings have been used successfully in geophysical drill rigs, grease mixers, belt conveyors, and upon oil-well pumping installations. One of the latest geophysical drill rigs is powered by two Ford V-8 engines, one of which is located under the truck hood and the other mounted on the truck bed. The engine mounted on the truck bed drives through a hydraulic coupling to the slush pump. The hydraulic drive in this instance absorbs much of the variation and load imposed by the duplex pump action and smooths out the flow of mud to the drilling string. The motor mounted under the truck hood drives the rotary table and the hoist drums through a hydraulic coupling. It is reported that much smoother rotary table operation is obtained from the geophysical drilling units on which hydrau-

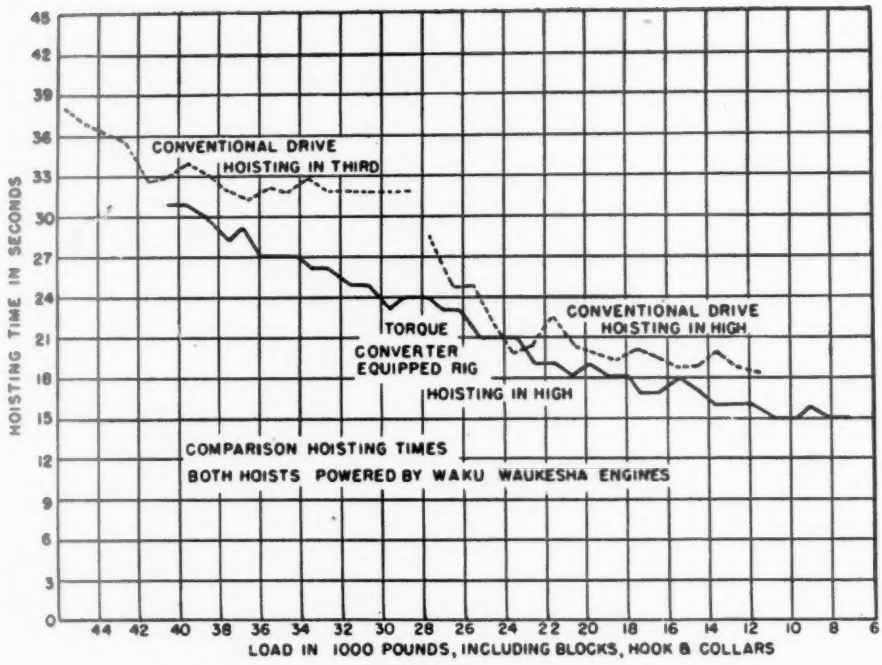


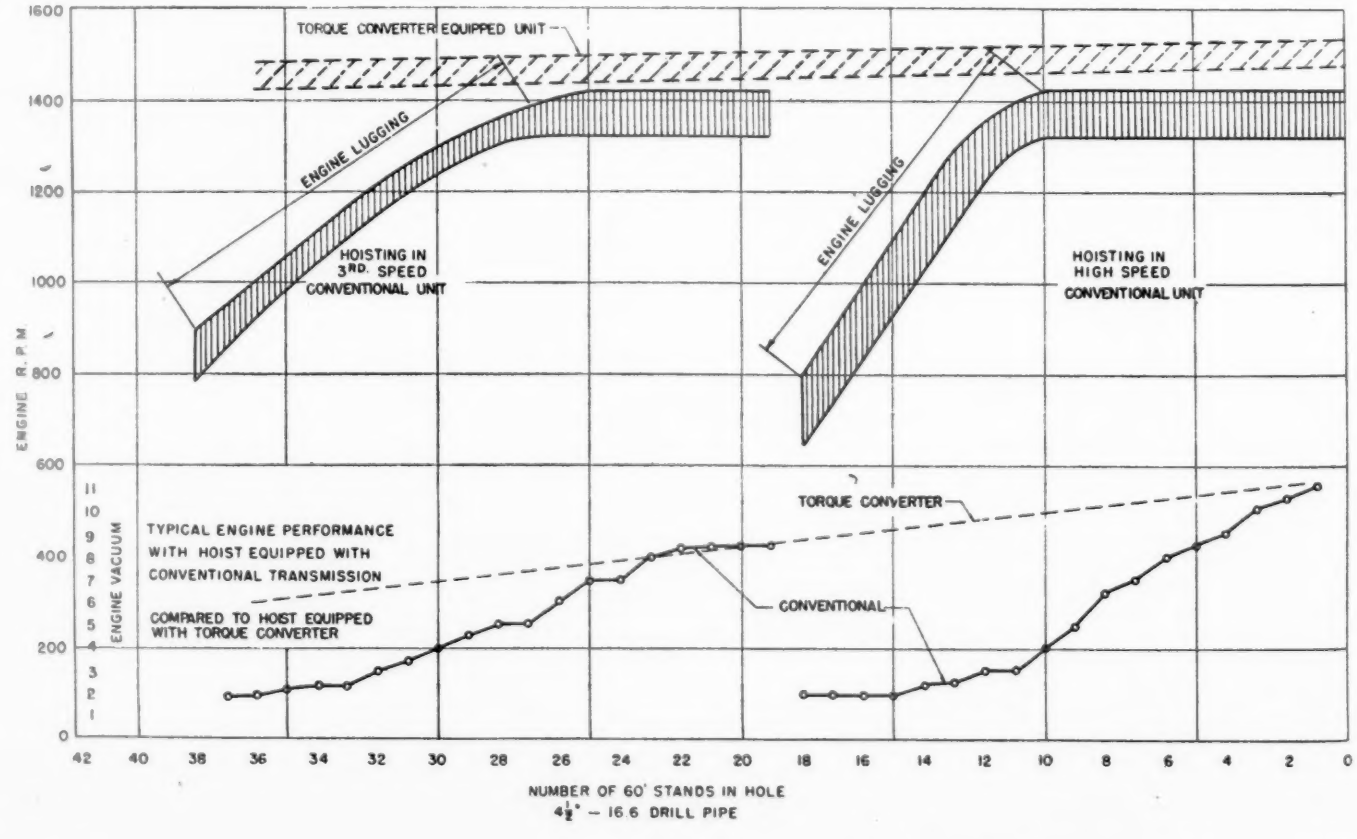
FIG. 5

lic couplings are incorporated and smoother hoisting is obtained. The coupling used is the filled type without any provisions for external cooling. There has been no overheating either on the pump or hoisting unit. Hydraulic couplings were installed on electric motor-driven grease mixers when the conventional direct connected unit caused excessive maintenance costs while mixing heavy grease. The maintenance costs have been reduced to an unbelievably small figure since the application of a hydraulic coupling between the electric motor and the grease mixing machinery.

One of the most interesting applications of the traction type hydraulic coupling was in connection with an oil-field pumping installation. This type of installation is still in the experimental stage and there are still mechanical problems to be worked out before it will make a satisfactory installation for universal application. The initial tests have proved that the internal-combustion engine operation is greatly improved when a hydraulic coupling is installed as the power take-off of the engine. The variation in engine rpm per stroke of the pumping unit is reduced by approximately 50 per cent and the engine vacuum variation is also greatly reduced. The reduction in variation and speed of the engine results in operation at a lower bmep. Dynagraph cards taken on wells before and after the installation of a hydraulic power take-off indicate that one can expect to obtain lower maximum polished rod loads and probably higher minimum polished rod loads. (Fig. 1) This will, of course, result in lower maximum stresses in the rods and a smaller magnitude of reversal of stress, both of which should improve sucker rod life. Tests made to date indicate that one can expect approximately a 10 per cent reduction in the maximum polished rod load if a hydraulic coupling is installed. It is impractical to start an air-balanced unit with an engine equipped with a hydraulic coupling, provided the air pressure in the unit is materially under the normal counterbalance pressure. This is a definite disadvantage and suitable combination of friction clutch and hydraulic coupling is being developed to overcome this problem.

● **Limitations of hydraulic couplings.** Hydraulic couplings are best fitted for those drives in which the prime mover is operating at a uniform speed over long periods of time and where the output speed and torque are fairly constant. Couplings are not suitable for operating at various input speeds or on loads where the torque requirements change rapidly.

FIG. 6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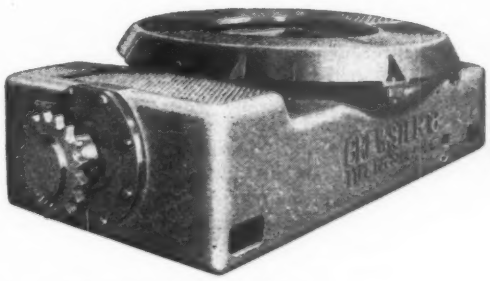

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An examination of the typical performance curve of a hydraulic coupling driven by an electric motor shows that the coupling output speed stalls under full torque at about three quarters normal prime mover speed. This prevents using the coupling at reduced prime mover speeds.

● **Characteristics of hydraulic torque converters.** Hydraulic torque converters consist of three basic members. The impeller, or pump, provides a means of imparting kinetic energy to the fluid as in the coupling, but in this case the pump is so designed that it will operate in one direction only. The turbine consists of several sets of blades, which absorb the energy of the fluid. Between each set of turbine blades is a set of reaction blades that are stationary and that redirect the flow of fluid from one set of turbine blades to the next. The reaction blades and turbine blades are very similar in appearance to the blades in a conventional steam turbine and the impeller has the appearance of a simple centrifugal pump. The torque converter is not reversible, nor can the driven or turbine blade be used as driving members.

The output and input members of a torque converter are very different in appearance, and the output and input speeds and torques are also very different. The output speed of the torque converter varies from full engine speed at zero torque to zero speed at five times engine torque. Thus we can see that the converter runs at zero efficiency both at stalled output speed and when the output speed equals the speed of the prime mover. The hydraulic torque converter is a very successful hydraulic transmission between these two limits. One of the first reactions to the converter is the loss of from 15 to 25 per cent of developed horsepower when working in the recommended speed limits of the hydraulic unit. The converter efficiency does not tell the entire story for one must compare the work done in a day's time, as well as fuel consumption.

The torque converter is essentially a hydraulic transmission capable of developing torques varying from full prime-mover torque at about three-quarters speed to five times prime-mover torque at stalled output speed. A drive of this type is useful in any operation requiring repeated changes in torque requirements, as it automatically selects the proper output torque and output speed for any load within its working limits. Hoists of all natures are most logical applications for torque converters, but study reveals many other suitable applications.

The most popular application of hydraulic torque converters in the oil industry has been in connection with drawworks and production hoists and satisfactory installations have been made upon sand reels, slush pumps, special service pumps, and cementing pumps.

● **Application of torque converters to pumps.** The installation of a hydraulic torque converter to a slush pump drive is one of the newer and more interesting installations. The introduction of the hydraulic torque converter allows the operator to run his engine continuously at an efficient speed with the slush pump automatically operating at the maximum speed obtainable for any given pressure produced in circulating the fluid. The pump performance in an installation of this nature will vary from large volumes and low pressures while a surface hole is being drilled to higher pressures and lower volumes as the hole increases in depth. With the hydraulic torque converter equipped slush pump drive, the output fluid horsepower of the pump will be fairly constant over a wide range of pressures and volumes, with the horsepower increasing as the pressure increases and the volume decreases, resulting in increased hydraulic horsepower when it is required on the deeper portions of the well.

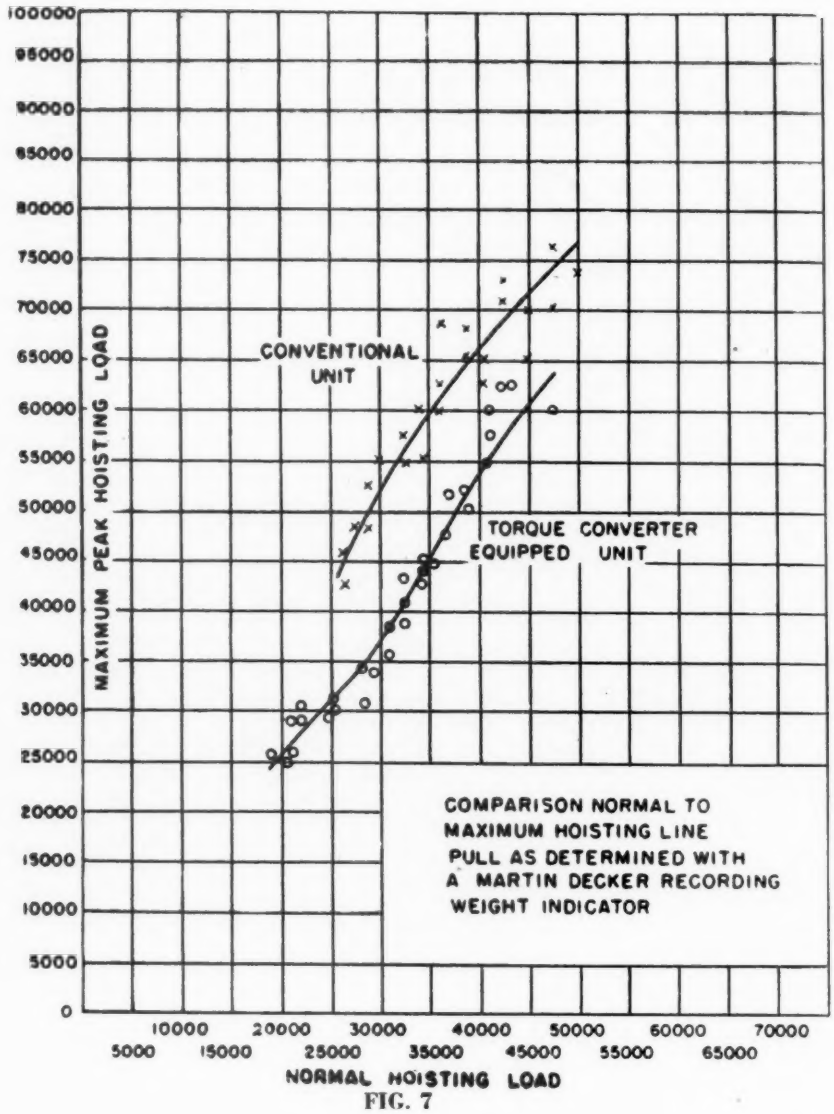

FIG. 7

A field test was made on a 7½ by 12 Gardner-Denver slush pump equipped with full-size liners and powered by a Waukesha W.A.K. engine. Water was used as the fluid and flooded suction was provided on the pump. (See Fig. 2.) The discharge volume was controlled through an adjustable bean valve. With the valve wide open, the pump operated at 56 spm, or approximately 460 gpm, when working against 300-lb. discharge pressure. As the bean was progressively closed, the pump slowed down and the pressure increased until 825 psi was developed at 32 spm, or 260 gpm. During this entire run the engine speed was practically constant, varying from 1450 rpm at 56 spm on the pump to 1425 rpm at 32 strokes on the pump. The engine manifold vacuum varied from 6 in. at high output speed to 5 in. in low output speed. During this test the hydraulic horsepower developed was 97 at 56 spm, 110 at 48 spm, 122 at 41 spm, and 125 at 33 spm. This shows that the maximum horsepower is available as the well deepens and the full horsepower is required.

Torque converters have also been applied to special purpose pumps where the operator requires extremely high pressures and small volumes for a portion of his work, and increasing volume with decreasing pressure for other portions of his work. One installation of this nature is used in connection with clean-out work on gun perforated wells. Pressures in excess of 5000 psi are developed with a 5-in. by 10-in. cementing pump. (See Fig. 3.) These pressures are transmitted through the tubing and against the plug gun perforations between packers set approximately 1 ft. apart. Pressure is built up in the system by

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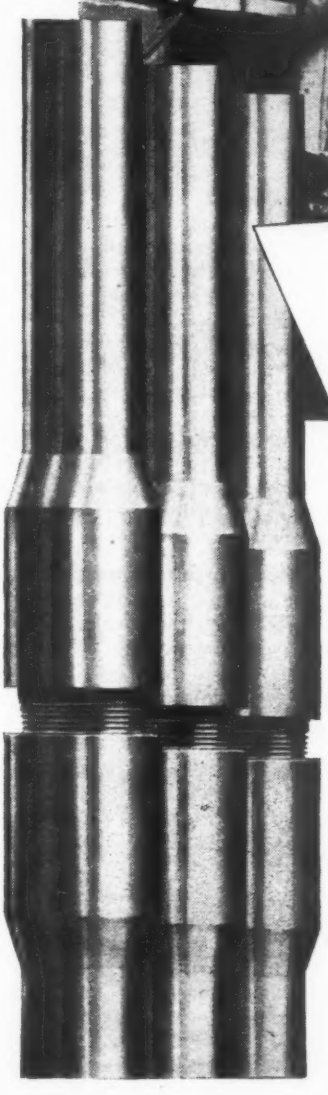

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opening the throttle on the internal-combustion engine until sufficient pressure is obtained to break circulation through the plugged gun perforations in a reversed direction. As soon as circulation has been broken, the pressure requirements drop and the slush pump speeds up without any manual manipulation. With the full throttle setting on this particular engine, a maximum pressure at stalled pump speeds in excess of 5000 lb. can be obtained and an increasing volume and decreasing pressure can be provided until the volume approaches 125 gpm at 1000 psi pressure.

The reverse of this requirement is on oil-well cementing units, where large volumes and low pressures are required to displace the cement slurry into the well and high pressure and low volume is required for squeeze operations. The latest internal-combustion engine power cementing unit is powered by a 200-hp. engine located under the hood of the truck. This motor transmits power to the truck wheels in the conventional manner and transmits power to the cementing pump through a hydraulic torque converter. The combination of increase in torque produced in the converter, and manipulation of valves that make it possible to use only 3 of the 6 cylinders in the pump, provides for delivery of between 280 gpm at 500 psi to more than 15,000 psi at stalled pump conditions.

● **Application of torque converters to hoists.** Hydraulic torque converters have been installed on numerous hoists in the oil-field, construction, and logging industries. In the oil fields they have been used on hoists ranging in size from well-servicing machines powered by single 60-hp internal-combustion engines to moderate depth drawworks installations powered by two engines, each developing in excess of 200 hp. A torque converter applied to hoisting equipment will provide three advantages in operation. First, the converter makes it possible and practical to do many operations that are almost impossible with a conventional internal-combustion rig. Recently one of the drilling contractors was endeavoring to set a string of casing with a rig equipped with two torque converters. The casing became stuck approximately 150 ft. off bottom. For eight hours this contractor's driller raised and lowered the casing while fluid was being circulated to wash out the obstruction. During this time the driller was not required to touch his brake or clutch mechanism, except when installing a new length of casing. The entire hoisting and lowering operations were controlled with the engine throttle operating through the torque converter. Opening the throttle slightly would cause the casing to be hoisted slowly. Closing the throttle a small amount would hold the casing suspended and motionless, and closing the throttle a little more would allow the casing to descend into the hole against the braking action of the converter. Bailing operations are also carried on in much the same manner, controlling the upward and downward motion of the bailer with the engine throttle and torque converter. When fishing a continuous and uniform line pull can be exerted through the torque converter by setting the engine throttle at any desired opening. If the fish moves slightly, the torque converter will spool the line and when the stalled equilibrium point is reached, it will maintain the line pull exerted before the fish moved. Operations of this nature are greatly simplified when a torque converter is used in the installation.

Shock loads are also greatly reduced through the entire drilling unit. In hoisting the sequence of operations on a torque converter rig is to engage all clutches and open the engine throttle, thus picking up the load smoothly through the hydraulic torque converter. Coring and directional drilling at low rotating speed and high torque are also practical and smooth on rigs equipped with converters. Hoisting time is reduced on rigs equipped with hydraulic torque converters due to the fact that the operator is always hoisting at the maximum speed for any given load.

Field tests were made of comparable pieces of drilling equipment to obtain relative hoisting speed on those units equipped with converters as compared to those units equipped with conventional drives. The tests were made by checking the time required to hoist each individual stand. The time interval chosen was from the instant the elevator contacted the offset of the pipe to the instant the driller closed the throttle at the end of the upward hoisting cycle. This interval was chosen to eliminate as nearly as possible the human element and obtain the actual mechanical advantage in hook horsepower. Investigations prove that in general the hydraulic torque converter equipped rigs hoisted a given length of pipe faster than conventional rigs. (See Figs. 4 and 5). The reduction in hoisting time per stand was but a few seconds, but the overall reduction in hoisting time was reduced from 10 to 25 per cent for a given number of stands of pipe. The study of these field tests clearly revealed the fact that there are conditions under which a conventional rig will hoist faster than a converter equipped rig, but the overall hoisting cycle favored the converter equipped rig. The conventional rigs approached and some times exceeded the converter equipped rig performance as the load hoisted becomes light. This is due to the fact that the engine is developing full horsepower in both cases and the converter losses are eliminated. It is interesting to note that the driller on both converter equipped and conventional rigs sometimes had to throttle back in hoisting light loads in order to reduce his hoisting speed for safety.

A study was also made of engine operating characteristics while checking the hoisting time. (See Fig. 6.) The engines on both the conventional and converter equipped rigs were checked under no-load conditions and they both operated at between 1600 rpm and 1700 rpm. Under hoisting conditions the torque converter equipped engine consistently obtained a speed of between 1450 and 1500 rpm. This speed was obtained within one-half second after the throttle was opened. The engine vacuum was never reduced to below 6 in. From this we see that the torque converter equipped engine develops its maximum horsepower, operates at its recommended speed, and is always running with a suitable intake manifold vacuum when it is equipped with the hydraulic torque converter. A similar engine operating on a conventional rig was lugging at under 6 in. of vacuum for over one-half of the hoisting time. The engine was operating at between 700 and 1400 rpm most of the time. These lugging conditions with low engine manifold vacuum and low operating speeds are harmful to the engine and prevent it from producing its full rated horsepower. A study of the engine speed curves on the torque converter equipped unit and the conventional unit explains clearly why more hook horespower is obtained when driving through the converter, even though there is a loss in power in the converter.

Martin-Decker recording weight indicators were attached to the dead line while making the time studies. A study of the recording charts showed clearly that the impact load as recorded by the maximum line pull on the indicator was greatly reduced in those units equipped with a torque converter. (See Fig. 7). A chart showing the comparison of normal to maximum hoisting line pull was plotted using the average uniform dead line pull as the normal hoisting load and the peak line pull recorded while starting the load as the maximum hoisting line pull. A 30,000-lb. normal hoisting line pull on a converter equipped unit was accompanied by a 37,000-lb. peak line pull, whereas the conventional unit built up a 55,000-lb. peak line pull. Undoubtedly much of the impact load had been absorbed in the drive and wire line before this load was transmitted to the dead line, but it is a definite indication of the reduction in shock load obtained when a converter is installed. Further proof of this reduction in shock load is obtained from the consistent reports that converter equipped rigs obtain in from 2 to 5 times the chain life obtained under similar drilling conditions on rigs without converters.

● **Limitations of hydraulic torque converters.** Care must be used in selecting the ratio of all drives in connection with torque converters in order that they may do most of the work in the efficient range of the converter. The high torque developed in the output shaft also places added loads on conventional gear trains installed in many pieces of machinery. The loss of power in the converter makes this type of drive undesirable in those units operating at their maximum horsepower capacity and relative uniform loads for long periods of time.

Direct drive hydraulic converters are practical for those installations where it is necessary to start heavy loads with varying torque requirements and then proceed at a uniform torque requirement for a comparatively long period of time. The direct drive converters are

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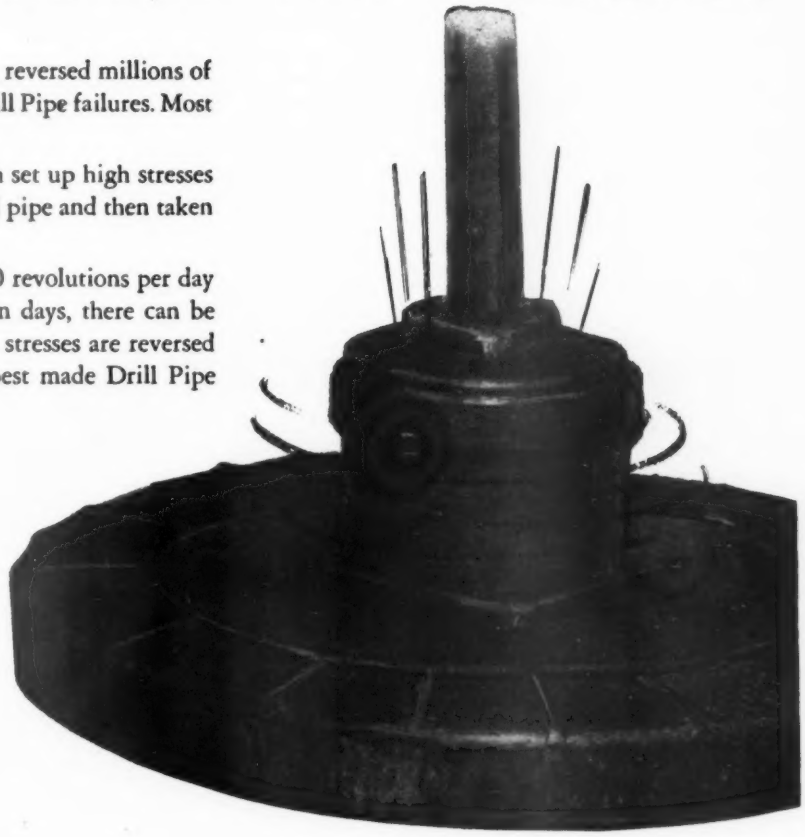

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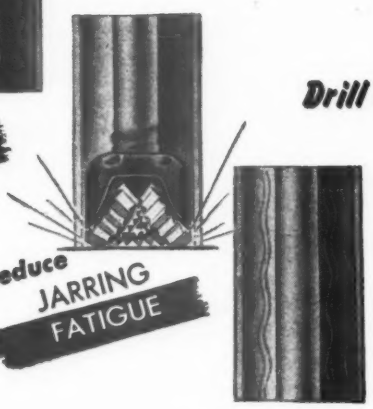

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used for buses, rail cars, and similar mobile pieces of equipment, and it is likely that they will be used in special-purpose trucks throughout the oil fields.

● **Basic principles of hydro-static drives.** The hydro-static drives are essentially fluid pumps and fluid motors of either constant or variable volume and pressure construction. The pumps impart pressure to the driving fluid, which in turn is piped to a fluid motor. This type of drive has often been compared to an electric generating set and an electric motor. The prime mover would drive either the fluid pump or the generator. The energy is transmitted into electricity through wires as volts and ampere or as fluid through tubing as volume and pressure. The energy is delivered to either the electric motor or the fluid motor and the final drive is made. One big advantage of the hydro-static drives is the simplicity of the installation. A small V-belt on chain drive taken off on a countershaft provides an adequate source of power for the fluid pump. Comparatively simple piping will often eliminate complicated gears, chaining, and shafting and the fluid motor can often be direct connected to the final drive. Control of the motor is through a simple four-way valve that will regulate the volume of fluid transmitted to the motor and will also provide for direct reversing of the fluid motor.

● **Applications of hydro-static drives.** There are numerous applications of hydro-static drives in the oil fields. Many of the cementing units and geophysical units utilize fluid pumps and fluid motors for powering their auxiliary drives. On the geophysical rigs the pull down hoists and mud-mixing hopper are commonly driven with the small hydro-static units. On the cementing units it is common to drive the proportioners and the screw conveyors with this type of equipment.

Larger hydro-static units include the long stroke hydraulic pumping. In this case the hydraulic pump generally delivers the fluid to a hydraulic ram rather than to a fluid motor. Another interesting installation of larger type fluid motors and pumps is on a production rotary table in operation at Ventura. This unit consists of a Ford V-8 motor connected to a conventional gear transmission. The gear transmission is in turn connected to a fluid pump. The installation of the transmission between the motor and the pump allows the operator to develop various volumes and pressures from the pump. This prime mover and fluid pump unit is set at a distance from the well and the fluid is transmitted through high-pressure rubber hose. The rotary table unit is set in the conventional position at the well. It consists of a small rotary table, a great transmission, and a fluid motor. All controls for the fluid motor are located on a common sub-base upon which the rotary tables are mounted. This unit places the internal-combustion engine at a sufficient distance from the well to reduce fire hazard and it is reported to be giving satisfactory operation, using adequate range of table speed and torque.

● **Limitations of hydro-static drives.** Most of the hydro-static drives in use in the oil fields are of comparatively small horsepower capacity, although larger drives are being developed. The units are most adaptable for those installations where piping can save expensive power transmission equipment. The hydro-static drive does not absorb shock loading, which is one of the basic characteristics of hydro-kinetic drives. Control of the speed of a fluid pump through the variable volume valves is very simple, but the efficiency of the drive is in direct proportion to the speed. If the fluid motor is operating at full speed, it is operating at maximum efficiency for the unit, but if the speed is reduced to 50 per cent, one half of the fluid is being bypassed and the efficiency of the drive is therefore reduced by 50 per cent. Due to the fact that these units are generally in small horsepower sizes, this loss in efficiency is more than offset by the ease of handling and installing drive.

● **Conclusions.** Hydraulic couplings, hydraulic torque converters, and positive displacement fluid motors have been installed in many new applications within the last two years. Some have been installed in applications of an experimental nature and some of the experiments worked out well, others not satisfactorily. As more field experience has been accumulated, it is possible to predict with more accuracy the result of contemplated installations and one can anticipate the use of these drives in many new installations. ★ ★ ★

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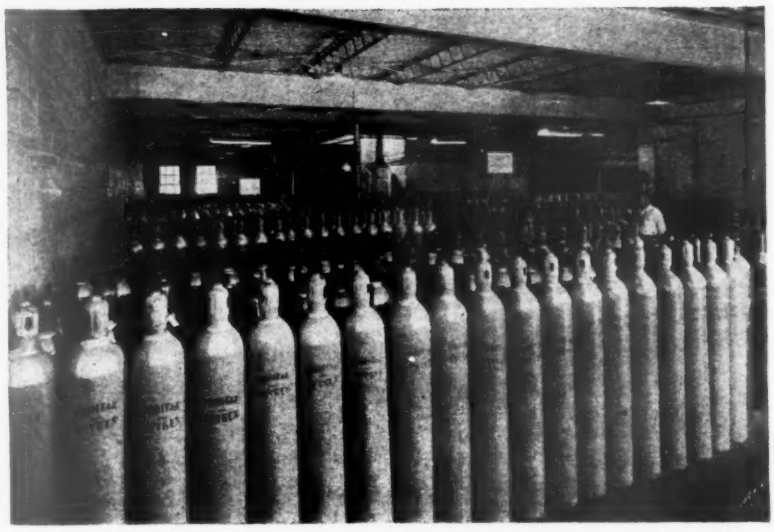

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New method to determine permeability

By
JOHN C. CALHOUN, JR.*

EXCLUSIVE

PERMEABILITY has been measured as a routine part of core analysis for many years, and it is considered to be a basic quantity for engineering considerations. The method by which permeability is determined has been standardized by the API in a code procedure[1], and this method, or a modification of it, is most commonly used for the determination of permeability. Other methods for measuring permeability have been used, the chief characteristics sought being rapidity of measurement. In a recent paper[2] a new method was described for the purpose of measuring gas permeabilities. The object of this present discussion is to give the mathematical derivation, details, and possible commercial application of this method.

In this discussion it is assumed that a gas permeability on a dry sample is the quantity sought, and no cognizance is taken from this viewpoint on the possible uses to which the measurement is to be put or whether or not such a measurement actually gives the permeability to reservoir fluids.

It has been shown[2, 3] that the permeability of a porous body to a given gas varies with the mean pressure of flow during measurement. Furthermore it is known that the permeability of a given sample is different for different gases. The determination of true permeability by a straight flow process therefore becomes a more tedious process than the measurement of a permeability value at a single mean pressure. The method to be described was instituted to give a rapid measurement at a single mean pressure and rapid adjustment to different mean pressures. It can be used for the determination of one given permeability at a definite mean pressure or of the true permeability after the manner of Klinkenberg[3].

The flow of gases through capillaries is very similar to the flow of gases through porous media. One can measure accurately the physical dimensions of a capillary and by measuring the flow of a gas through it, calculate the gas viscosity. This has been one method of measuring gas viscosity for some time. There were early developed[4] various methods employing pressure build-up or pressure decline in a closed vessel to take the place of volume measurement in these calculations. The techniques employed were of three types: (1) Maintaining a constant upstream pressure, usually atmospheric, and measuring the rise in pressure in an evacuated downstream vessel; (2) maintaining a constant downstream pressure, usually atmospheric and measuring the fall in pressure in a closed upstream vessel, and (3) simultaneously measuring the rise in pressure in a downstream vessel and fall in pressure in an upstream vessel.

In the measurement of permeability by gas flow, the viscosity of the gas is known and the physical constant of the conducting body is calculated. The same methods should be adaptable to calculating this constant as are used for viscosity measurement by flow through a capillary. This suggests one of the three above techniques. Some work has been done but unreported on permeability measurement by the second of these methods[5]. In the manner in which these methods would ordinarily be employed. the mean pressure is not a constant. They were discarded, therefore, in favor of a modification of the third technique above, by which the mean pressure could be held constant during measurement. This calls merely for making the volume of the upstream vessel of the same volume as the downstream vessel.

Consider a permeable body placed between two vessels under pressures P_1 and P_2, respectively, P_1 being greater than P_2. Consider that both vessels are closed so that all gas leaving the first vessel passes through the permeable body to the second vessel. Flow will ensue until P_1 and P_2 are equalized.

At any time the perfect gas law is used to express conditions in either vessel. Thus:

$$P_1V_1 = n_1RT_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$P_2V_2 = n_2RT_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

T_1 and T_2 can be made constant and equal. The volume of the vessels V_1 and V_2 are also constant. The changes in P_1 and P_2 are thus due to the change in n_1 and n_2. These equations are differentiated with respect to time to give a rate at which flow proceeds. Thus,

$$V_1\frac{dP_1}{dt} = RT\frac{dn_1}{dt} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$V_2\frac{dP_2}{dt} = RT\frac{dn_2}{dt} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now, since all the gas that flows from the first vessel must go into the second vessel, the change in mols per unit time in the upstream must equal that in the downstream vessel. Taking into consideration the relative direction of change:

$$-\frac{dn_1}{dt} = +\frac{dn_2}{dt} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

This statement is not exact unless the gas can be considered as incompressible. That is, the permeable body has pore space and a change of pressure within it will change the mols contained therein. The amount of error due to this fact is probably small, more so since it will be later developed that the mean pressure within the body remains constant.

The mean pressure of flow is defined as:

$$P_m = \tfrac{1}{2}(P_1 + P_2) \quad . \quad . \quad . \quad . \quad (6)$$

If it is desired to keep P_m constant during a measurement the requirement that must be met can be arrived at by differentiation with respect to time. Thus,

$$\frac{dP_1}{dt} + \frac{dP_2}{dt} = 0$$

or

$$\frac{dP_1}{dt} = -\frac{dP_2}{dt} \quad . \quad . \quad . \quad . \quad (7)$$

But, by combining equations (3), (4) and (5) we have:

$$V_1\frac{dP_1}{dt} = -V_2\frac{dP_2}{dt}$$

Therefore, equation (7) can be satisfied by choosing $V_1 = V_2$.

According to Darcy's law, the flow through the linear permeable medium is expressed as:

$$Q_m = \frac{k\,A(P_1 - P_2)}{\eta\,L} \quad . \quad . \quad . \quad . \quad (8)$$

Where Q_m is the volume rate of flow at pressure P_m, k is the permeability constant, η is the viscosity, L is the length of the medium, and A is the cross-sectional area of the medium. However, this volume rate of flow Q_m can be expressed as a molar rate of flow as follows:

$$P_m\,Q_m = RT\frac{dn}{dt} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Substituting this in equation (8) yields

$$\frac{RT}{P_m}\frac{dn}{dt} = \frac{kA(P_1 - P_2)}{\eta\,L} \quad . \quad . \quad (10)$$

As steady state flow has been assumed, $\frac{dn}{dt}$ is numerically equal to either $\frac{dn_1}{dt}$ or $\frac{dn_2}{dt}$. Therefore, equation (3) can be substituted in equation (10) to give:

$$\frac{V}{P_m}\frac{dP_1}{dt} = \frac{kA(P_1 - P_2)}{\eta\,L} \quad . \quad . \quad (11)$$

The subscript has been dropped from V because $V_1 = V_2$. P_2 can be eliminated from this equation by using equation (6). Thus:

$$\frac{V}{P_m}\frac{dP_1}{dt} = \frac{kA2(P_1 - P_m)}{\eta\,L} \quad . \quad . \quad (12)$$

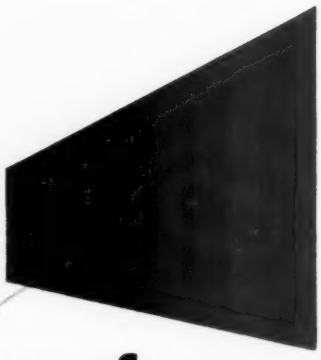
This is rearranged as follows for integration between limits of time zero and time t.

$$\int_{P_1}^{P_1'}\frac{dP_1}{2(P_1 - P_m)} = \int_0^t \frac{kA\,P_m\,dt}{\eta\,LV}$$

*Associate professor in petroleum engineering, University of Oklahoma, Norman, Oklahoma.

On marginal wells, where there is still considerable formation energy, McEvoy Gas Lifts are giving good production with amazingly little gas.

how this



utilizes ALL formation energy

GAS used while the well is self-producing is wasted. The unique operating principle of the McEvoy Gas Lift prevents this waste by closing all valves when the well starts producing on its own. Gas consumption is reduced and lifting efficiency increased. But, that is only one of the many advantages of a McEvoy Gas Lift installation. It gives unequalled overall efficiency by injecting all gas through the lowest uncovered valve regardless of changes in conditions. Every cubic foot of gas does the greatest possible lifting job.

Maintenance costs are low

1. The valve is simple and rugged in construction.
2. There is no surface equipment to get out of order.
3. Because of its automatic operation, McEvoy Self-Operating Gas Lift installation requires little more attention than a flowing well.
4. A well equipped with a McEvoy Gas Lift installation can degrade from an oil well to a salt water well without expensive pulling jobs or continuous readjustment.

It's easy to work on a McEvoy equipped well

1. The full-hole opening through McEvoy Gas Lift valves permits running paraffin knives, pressure bombs, etc.
2. If the well must be killed, fluid can be circulated down the tubing with no back flow through the valves, giving circulation to bottom.
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For complete information write for this catalog

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Because of its unique operating principle the McEvoy Gas Lift **automatically** adjusts itself to well conditions and works at peak efficiency all the time.

The schematic diagrams at the right show how the valves adjust themselves automatically to well conditions. Three valves are shown for illustration, but operation would be similar with more valves.

Condition A. This diagram shows well conditions before gas is turned on.

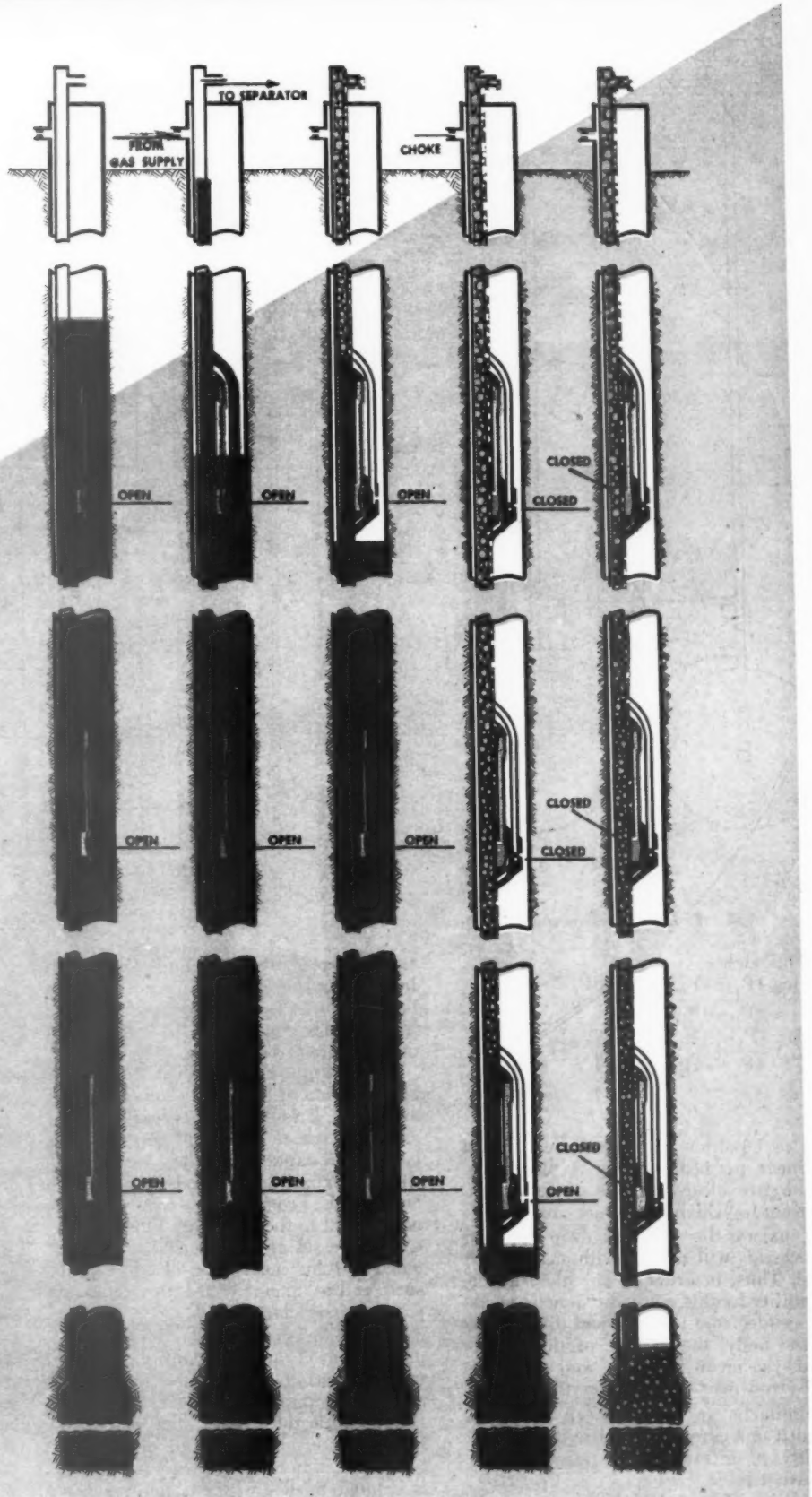
Condition B. Gas is being turned on but fluid level in casing has not yet uncovered port of first valve.

Condition C. The gas lift is producing from the first valve. Fluid level in casing is still receding. As the fluid level in the casing drops below each succeeding valve, the gas starts flowing through the lower valve and all upper valves are positively closed.

Condition D. Steady operating conditions have been reached. The lowest valve is admitting gas to the tubing. All upper valves are positively closed because the well fluid in the tubing at each upper valve is aerated.

Condition E. The well is producing enough formation gas to flow naturally. Notice that **all valves are closed** and **no gas is being used.**

A McEvoy Gas Lift installation uses gas **only** when it is needed—then, since it admits **all** the gas used through the lowest valve uncovered, every cubic foot of gas does the most efficient lifting job possible. That's why McEvoy installations consistently give the lowest possible gas-oil ratio regardless of well conditions.



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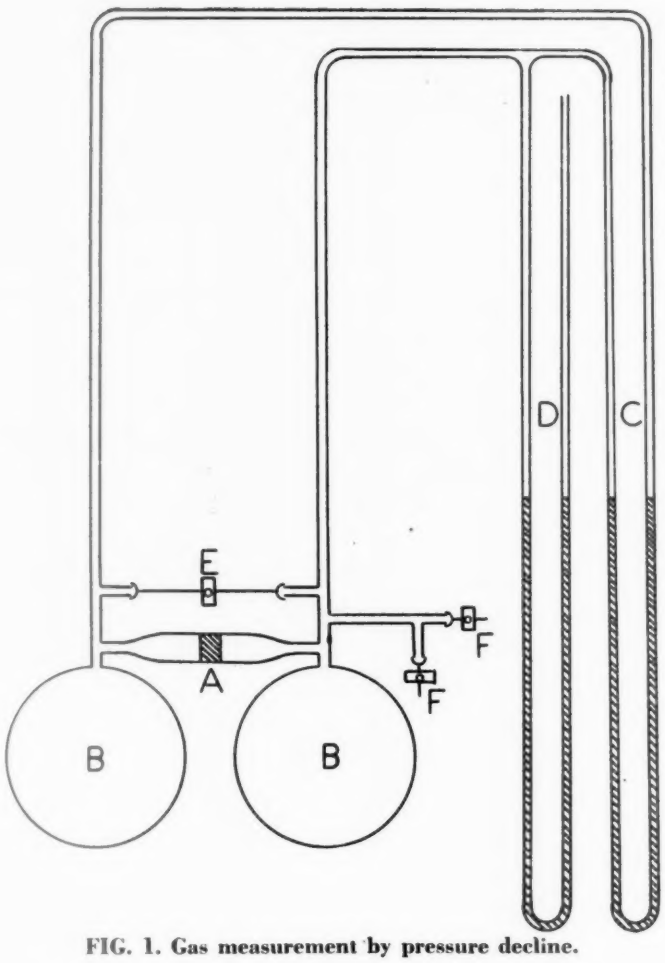

FIG. 1. Gas measurement by pressure decline.

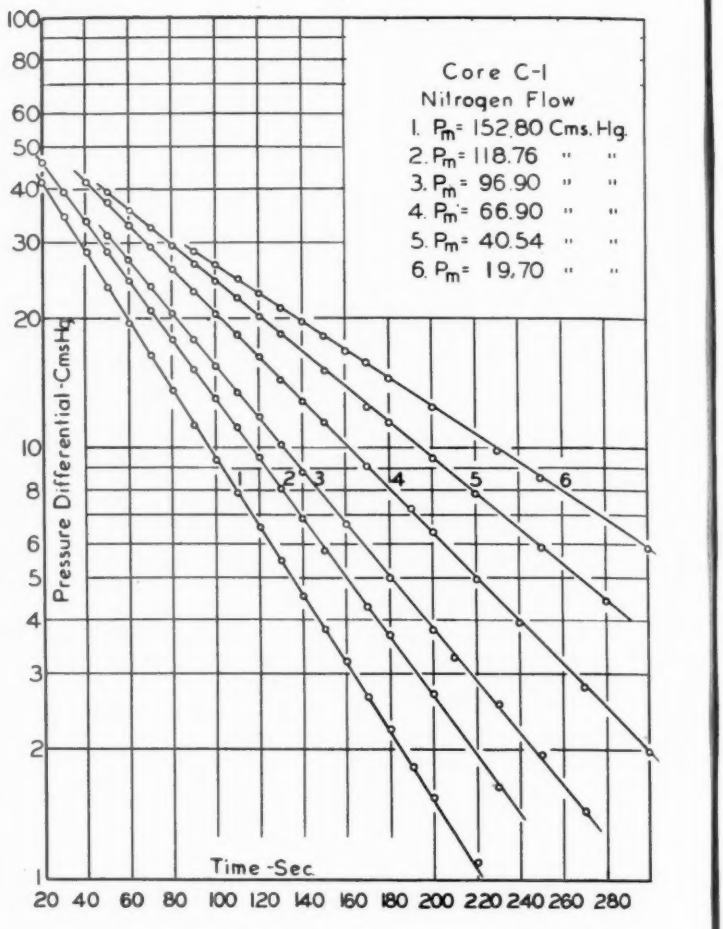

FIG. 2

This yields:

$$\frac{\tfrac{1}{2}\log\,(P_1 - P_m)}{(P_1 - P_m)} = \frac{kA\,P_m}{\eta\,L\,V}\,t$$

$$\text{or } \log\frac{(P_1' - P_2')}{(P_1 - P_2)} = \frac{2kAP_mt}{\eta\,LV}$$

. . . . . (13)

This equation gives the result that if a linear permeable body is placed between two closed vessels of equal volume across which a pressure drop $(P_1 - P_2)$ exists, the pressure drop between the vessels will fall logarithmically with time. Thus, in order to calculate a permeability by this method one need measure, aside from the physical dimensions of the body, the volume of the vessels used, the mean pressure, and the pressure drop over a time interval.

Similarly, an equation can be developed if one cares to measure the permeability of a radial core sample. This equation is:

$$\log\frac{(P_1' - P_2')}{(P_1 - P_2)} = \frac{4\pi\,h\,k\,P_m\,t}{\eta\,V\ln r_{2/r1}}$$

. . . . . (14)

A laboratory set up was made to measure permeability according to equation (13). A diagrammatic sketch of this apparatus in shown as Fig. 1. In order to measure the pressure drop and mean pressure, mercury manometers were employed. This is a violation of the condition $V_1 = V_2$, for the mercury rises and falls in the manometer limbs; however, by making the cross-section of the manometer limbs small the relative change in volume is small and the assumption of a constant V is valid.

Referring to Fig. 1, A was the permeable medium of from ½ to 2 cm in length and from 2 to 4 sq cm cross-sectional area. The vessels B were of approximately one liter capacity, and were connected with a bypass controlled by a screw clamp at E. From each vessel a side connection led to the differential manometer C. One vessel also connected to a manometer D for measuring absolute pressure, and to outside connections controlled by screw clamps at F.

The apparatus was charged with the gas to be used for permeability measurement by making one connection at F to a vacuum pump and the other to the gas supply while the bypass at E was open. By alternately opening and closing the two connections at F, the apparatus was evacuated, flushed with gas, and reevacuated. Finally, gas was charged in under about 30 psi pressure.

The desired data were then gathered after sufficient time had elapsed for the apparatus to come to a constant temperature in a water bath controlled by thermostats. The successive steps were:

(1) The bypass at E was closed.

(2) One connection at F was opened to the atmosphere until enough gas escaped to give the proper throw on the manometer C. The connection was then rapidly closed.

(3) Readings were taken on the manometer C as a function of time.

(4) When sufficient readings were obtained the bypass E was opened.

(5) The manometer D was read and at the same time a barometer reading was taken.

(6) The bypass at E was closed again as in step (1) and the succeeding steps were repeated.

Each time gas was bled from the system at step (2), a measurement was made under a new mean pressure. When atmospheric pressure was approached within the system, the bleed-off was made to a vacuum pump. In this manner mean pressures below atmospheric were obtained.

Step (3) required readings of the manometer with time and it was impossible to read both limbs at the same instant. Therefore, alternate limbs were read at equal time intervals. These were plotted, and the differential pressure for a given time was then read from the plot.

Figs. 2 and 3 show the type data that were taken. These graphs show the decline of pressure differential as a function of time at several mean pressures with the apparatus charged first with nitrogen and then with propane. The circles on these plots are actual data points, measured in step (3) above, at successive mean pressures. These plots of data substantiate the developed equation (13), which demands that the pressure differential decline logarithmically with time.

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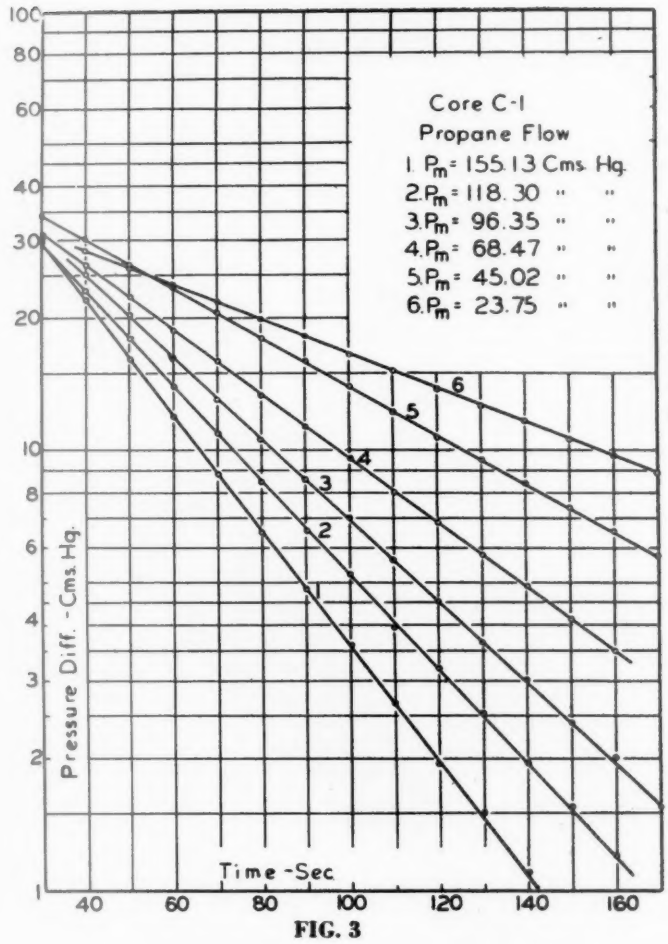

FIG. 3

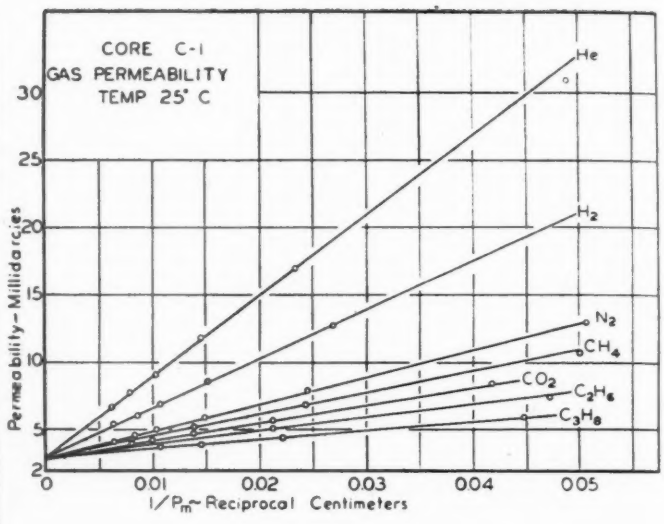

FIG. 4

To calculate the permeability, k, from equation (13), the slope of a decline for a given mean pressure in a plot like Fig. 2 was taken. The mean pressure itself was calculated from the readings of step (5). A value of V was found by filling the apparatus with a gas, the bypass at E being open, expanding this gas into an evacuated vessel of known volume, and reading the pressures before and after expansion. By using Boyle's law a value of twice V was computed from this expansion process. Viscosity data were taken from the literature, one value being used for a given temperature at every mean pressure of measurement.

It was demonstrated that P_m remained constant during a given run by recording its value at different times as the pressure differential declined. Table 1 lists such values for a typical run.

TABLE 1
Constancy of mean pressure

Pressure differential	Mean pressure
43.80 cm Hg	50.62 cm Hg
41.88	50.64
34.00	50.70
22.30	50.57
17.00	50.55
9.30	50.52

That this method gave an accurate value of permeability is demonstrated by such data as that in Fig. 4. Here have been plotted the values of permeability as calculated by equation (13) against $1/P_m$ on these measurements. The linear relationship found for each gas was as demanded by our concepts of permeability[2, 3], and a common value was found at infinite mean pressure. A determination of liquid permeability on this core also gave the value of permeability shown at infinite mean pressure. The meaning of the functions found in these graphs has been explained in a previous article[2].

It is apparent from the basic principle of this apparatus that it might readily be adapted to measurements on core samples on a commercial basis. This would be especially true if industry ever demands the measurement of a permeability after the manner of Klinkenberg. Any commercial apparatus must be sturdy, easy to operate even to the extent of being automatic, and be rapid. It is believed that the apparatus outlined here possesses all these details to a favorable degree.

The most obvious thing about measuring permeability by this method is that the same size vessels could not be used for all measurements. By equation (13) for measurements on samples of equal dimensions using the same gas at the same mean pressure and desiring the same relative accuracy on pressure differential, kt/V must be a constant. For a given V, a thousandfold change of permeability would mean a thousandfold change of t, which for uniform and fast measurements is too great. As a thousandfold change of $\log \frac{P_1' - P_2'}{P_1 - P_2}$ would be cumbersome, if not impossible, on a given installation, the only logical solution is to have a V that can be varied. This is easily accomplished by installing, for example, three different sizes of vessels on each side of the apparatus, any or all of which could be switched into the system by the turning of a valve. In running a permeability, observation could first be made with the smallest volume in the system, and larger volumes added as desired to give the proper operating decline of pressure differential.

Manometers would probably be cumbersome on an apparatus for commercial installation. A more desirable arrangement would be to measure pressure differentials by some sensitive mechanical or electrical means, for example, by means of a differential strain-type gage of the proper range. At the same time measurement of the time interval could be by electrical impulse. In this manner an electrical circuit could give a time interval as measured between two set pressure differentials, and the proper variance of time interval could be arranged by using the different values of V as outlined above.

It is not meant here to outline the details of how such a set-up could be made. The ingenious designer could undoubtedly devise means to read permeability directly from the rate of pressure decline. It is meant here only to indicate that the method presented offers good possibilities for obtaining the desired speed, accuracy, and simplicity of operation sought for in all routine testing equipment.

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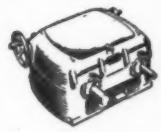

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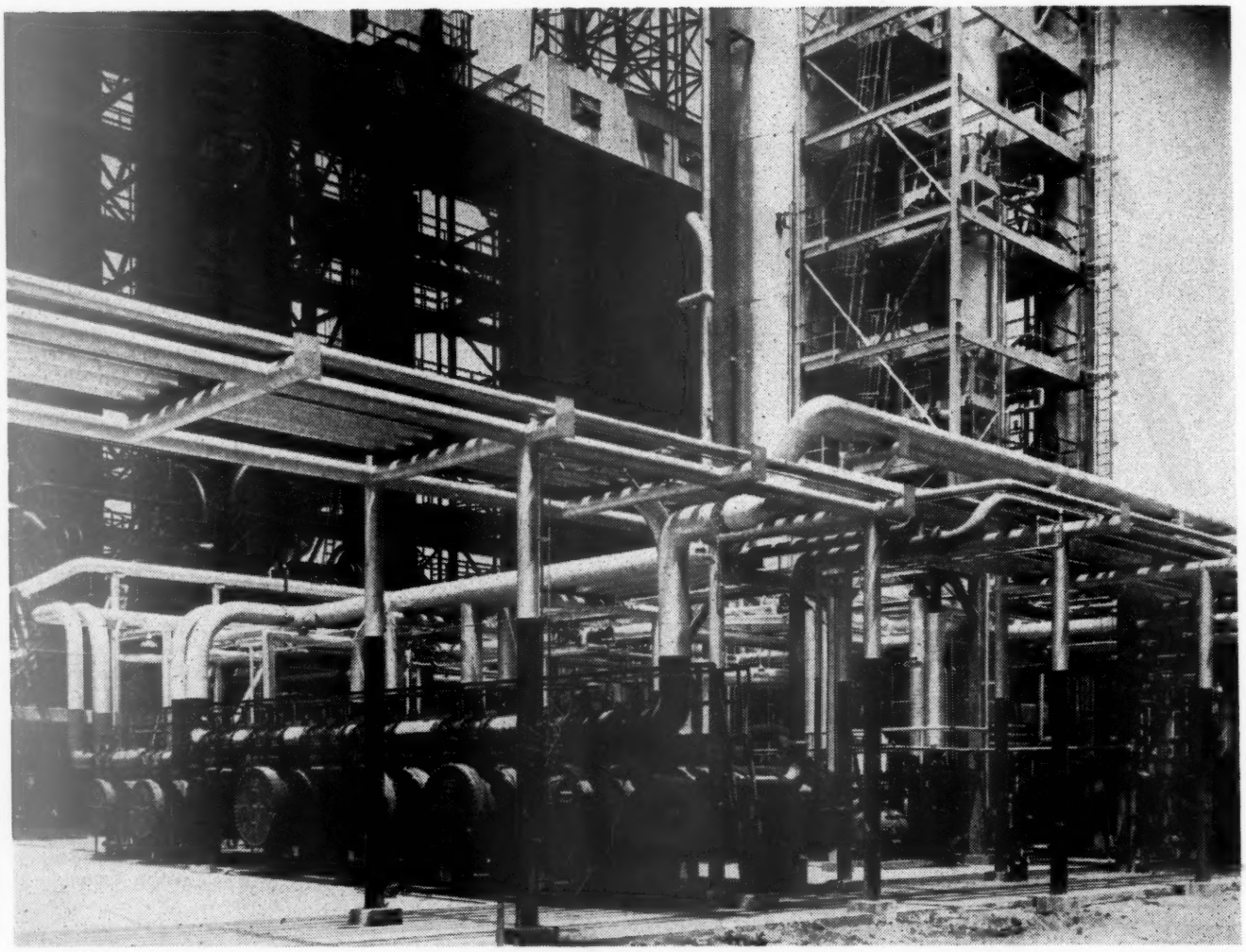


Feed exchangers with fractionating columns and coke drums in background.

Delayed coking unit at Torrance refinery

By **RANDAL MAAS** and **R. E. LAUTERBACH,** General Petroleum Company

● **Introduction.** With the diesel engine, the household burner, and the light oil cracking units all competing for the intermediate or gas oil fractions, the general trend in refining is toward a more extensive cracking of the residuum fraction. It has been estimated[1] that this trend, in the next 10 or 20 years, will reduce the percentage residuum from the present 26 to some 10 per cent. It is not expected that this cracking of heavier stock will so much replace light oil cracking as that it will provide the requisite charge stock.

The General Petroleum Corporation has contributed to this trend by installing a 15,000 bbl per day delayed coking unit to process 300″-700″ SSF/122 F straight run residuum. The gas oil thereby obtained will serve to supply part of the feed stock to the four TCC units. The coking unit was designed, engineered, and constructed by the M. W. Kellogg Company, and incidentally is the largest unit of its kind in the world. Coking operations were started July 26, 1946, culminating a successful and relatively simple startup operation.

It is the intent of this article to describe the coking process with particular emphasis on the equipment used therein. Some of the initial operating data also have been included.

● **General process.** The description of the general process may best be followed by referring to the flow sheet, Fig. 1. The cracking portion of the coking unit is divided into two sections each with its own furnace and pair of coke drums to be used alternately. The cracked products from the two cracking sections enter a common bubble tower for fractionation into an overhead product of gasoline and lighter, three gas oil draw products, and a bottoms recycle product. The straight run residuum charge, or reduced crude charge as it is also called, is introduced into the bubble tower for further fractionation with the bulk of it appearing in the bottoms for furnace charge. Three steam strippers for the sidedraw streams and a gasoline debutanizer complete the fractionation equipment.

● **Physical equipment. Furnaces.** As was indicated above, two duplicate fur-

[1]Hulse, S. H., *Oil & Gas Journal*, June 15, 1946, p. 98.

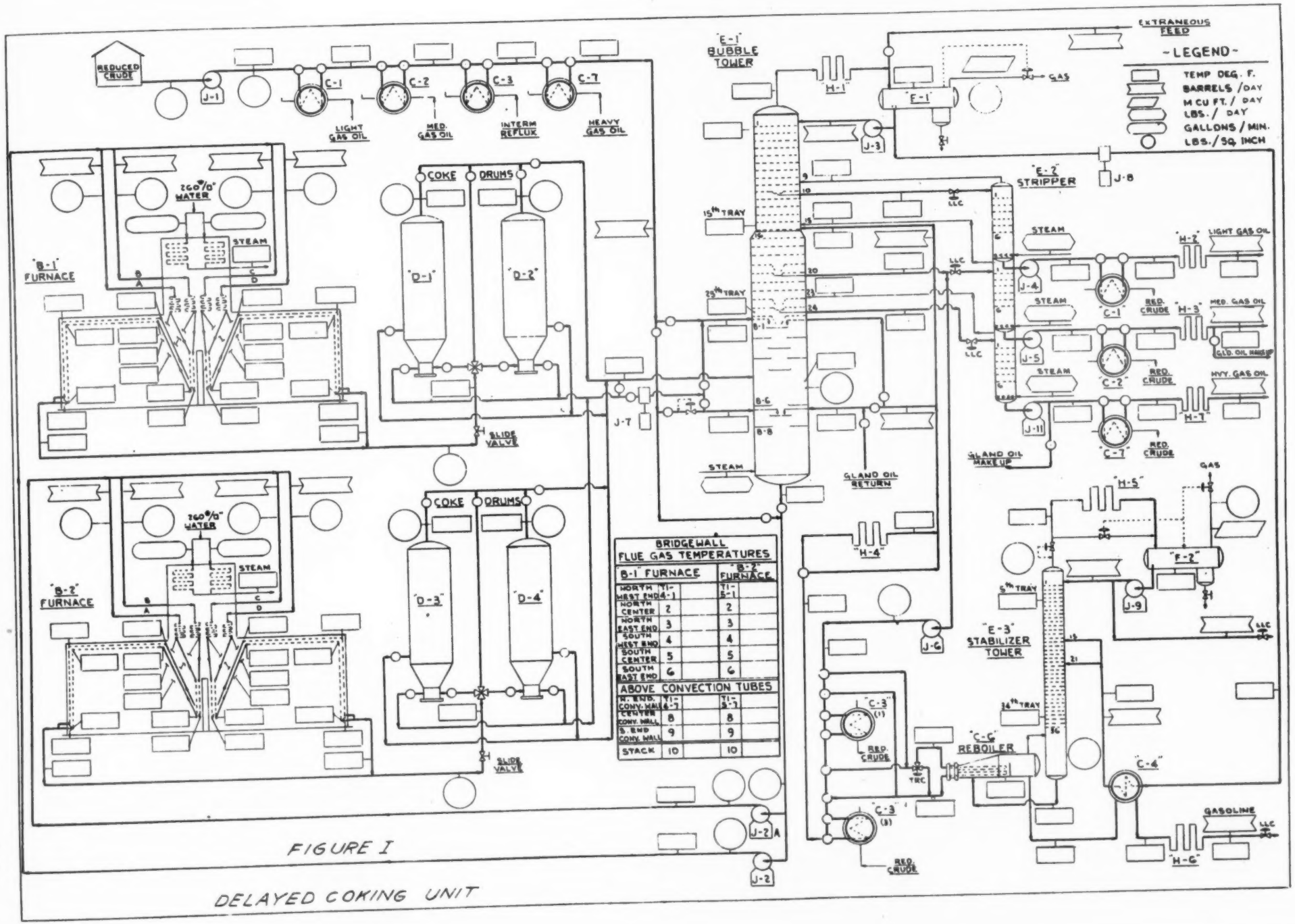
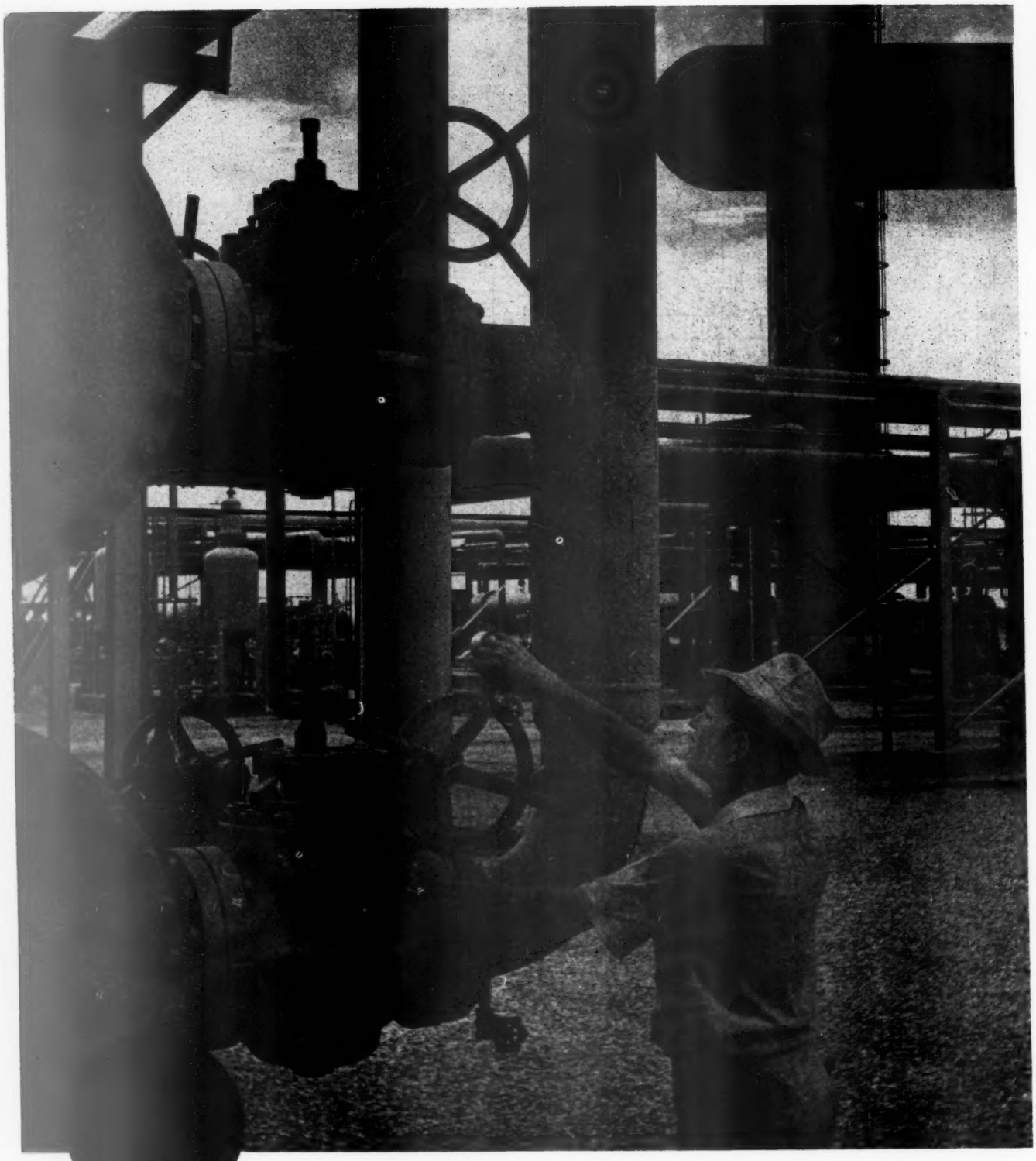


FIGURE I

DELAYED COKING UNIT



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IN every petroleum operation, *safety* is the first objective to be considered. *Safety* to the employed operators, *safety* in all plant and field operations and *safety* in maintaining uninterrupted flow schedules—these demands are to a large extent predicated upon the ability and stability of the valves.

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A valve must always open and close easily. Otherwise safety is impaired. Nordstrom valves, by their simple, direct rotary movement and hydraulic lubricant action, are easy to operate. They may be operated more quickly, by reason of their simple quarter-turn.

The inherent design of Nordstrom valves insures *extra safety.* The bodies are proportioned to provide ample cross area for the maximum pressure of each respective range. The rotary plug, accurately lapped within the body, insures positive

closure. The plug and body form a compact and rugged assembly having greatest simplicity.

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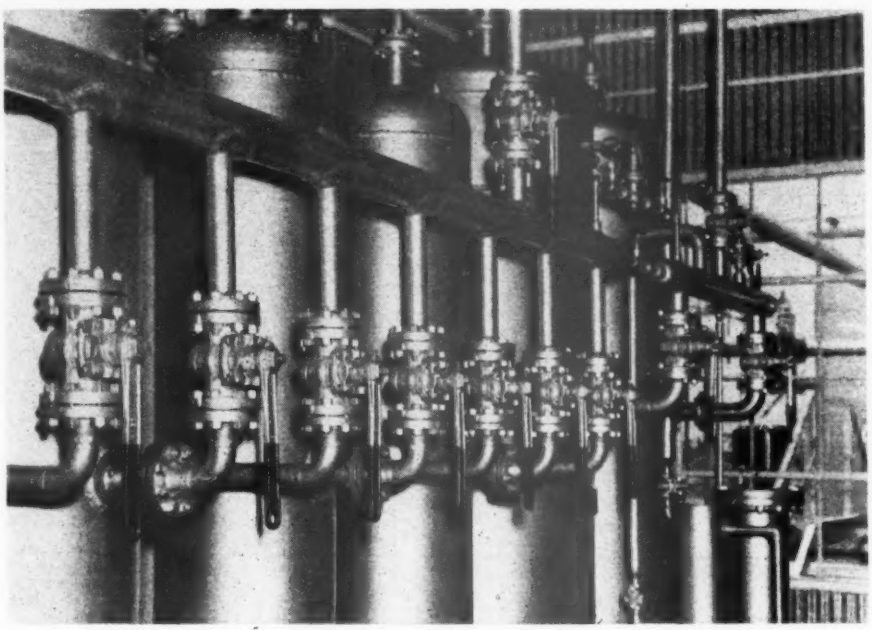
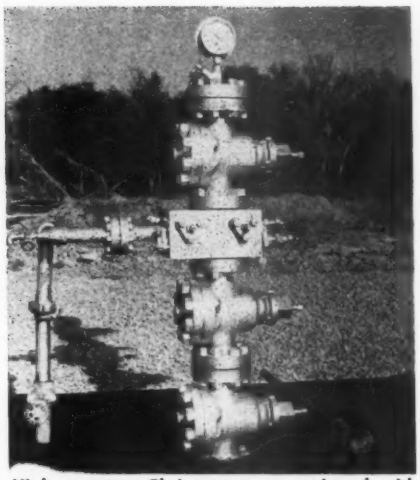
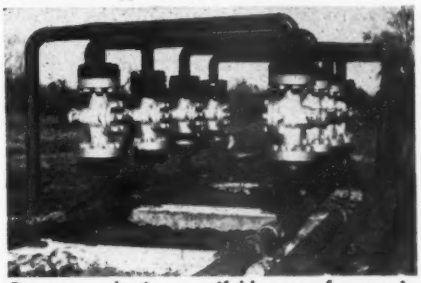


Installation of Nordstroms on engine air-starting tanks in a Texas natural gasoline plant.



High pressure Christmas tree, equipped with Nordstrom Hypreseals, at Jefferson Parish, La.



Pressure reduction manifold, one of many in Bay City, Texas, field, with Nordstrom valves.

Nordstrom 3000-lb. valve on line to injection well, at La Gloria, Texas.

Mud-encrusted Nordstrom valves on mud outlet to pit, on a Gulf Coast rig.

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naces have been provided, one for each pair of coke drums. The distinguishing and highly desirable feature of a delayed coking unit is the delaying of the coking until the charge reaches the soaking chamber (coke drum). To accomplish this the furnaces are designed for a low residence time and consequently a high rate of heat pickup. Because of the high heat level (600 F) of the furnace charge, the oil tubes were restricted to the radiant section and the hotter portion of the convection section. Heat economy is realized through the use of water tubes for steam production in the colder portion of the convection bank.

In general each furnace has four separate coils that join outside the firebox into a common transfer line. The 3¼-in. O. D. tubes are 42 ft long and have a wall thickness of 7/16 in. Alloy tubes of 9 chrome—1.5 moly are used in the radiant section and to shield the convection bank. The remaining tubes in the convection bank are 5 chrome—0.5 moly. Heat is supplied by 16 Zink combination oil and gas burners situated in the end of the firebox.

● **Waste heat boiler.** As was indicated above, the temperature of the furnace charge was too high to realize a good heat economy with oil tubes alone. Therefore, a waste heat boiler, with its lower receiving temperature, has been added in the convection bank of each furnace to reduce the temperature of the flue gases. This heat pickup serves to supply some 75 per cent of the plant's steam requirement. The outlet of the coils from the two furnaces enter a common steam drum from which a single boiler feed pump takes suction to circulate the water through both coils. A level control maintains the water level in the drum by admitting treated water from the refinery main boiler plant feed pumps.

● **Coke drums.** A continuity of operation is maintained through the use of a pair of coke drums for each furnace, one drum being in coking service while the other is being decoked. Each drum is 17 ft in diameter and 80 ft in height with 61 ft of straight section. For protection against corrosion the vessels are lined with a 7/64-in. thickness of Type 405 stainless steel, the lining being resistance welded to the shell. In addition the upper half of the shell is ⅞ in. thick and the bottom half 1 in. thick. To subject a vessel of this size to the changing temperatures of blocked operations requires, of course, that it be fully stress relieved and its welds X-rayed.

Alloy steels were also used in the principal piping to and from the coke drums. The transfer lines were fabricated from 9 chrome—1 moly pipe and the vapor lines from the drums to the bubble tower from 5 chrome—0.5 moly. Portions of the drum condensate lines, the side vapor lines, and the bypass lines are also of alloy steel.

● **Bubble tower.** The 100-ft high bubble tower is 11 ft in diameter in its upper section and in its bottom section is enlarged to 12 ft 6 in. to accommodate the increased downflow occasioned by the introduction of the intermediate reflux and the reduced crude feed. Fifteen cast-iron bubble trays are used in the upper section and in the lower section ten Type 405 stainless steel bubble trays with eight cast-iron baffle trays below them in the potential coking region. The shell thickness varies from 9/16 in. to 15/16 in. and is protected throughout by a 7/64 in. Type 405 stainless steel strip-welded lining.

To reduce construction costs the three sidedraw steam strippers are contained in one 4-ft 6-in. by 56-ft shell appropriately divided into three 6-bubble tray sections. The available hydrostatic heads dictate that the strippers be used in the same vertical order as the draw; that is, with the top draw in the top stripper, etc. The strippers are unlined and the trays are all cast iron.

It will be noted that the entire hot oil section of the plant is protected from corrosion through the use of alloy steels. In the bubble tower region, however, some exceptions were made after considering the corrosion tendency and ease of replacement.

● **Debutanizer.** The design of the 4-ft, 36-bubble tray debutanizer follows the conventional pattern. The tower is unlined and all trays are cast iron. To accommodate possible depropanization, the design working pressure was set at 330 psi.

● **Heat exchange equipment.** Some characteristics of the shell and tube heat exchangers are tabulated in Table 1.

Following our general practice open section condensing and cooling equipment is used throughout. Open sections, situated in a 45 bay atmospheric cooling tower, were provided as in Table 2.

TABLE 1. Heat exchangers.

Shell side	Tube side	No. of bundles	Total surface, sq. ft.	Tube material
Reduced crude	Light gas oil	2	2,480	Steel
Reduced crude	Heavy gas oil	2	2,480	Steel
Reduced crude	Intermediate reflux	4	12,880	Steel
Reduced crude	Fuel oil	2	4,350	Steel
Stabilized gasoline	Stabilizer feed	2	1,090	Steel
Stabilizer bottoms (stabilizer reboiler)	Intermediate reflux	1	2,000	Steel

TABLE 2. Condensers and coolers.

Service	No. of bundles	Total surface, sq. ft.	Tube material
Bubble tower overhead	18	10,200	Admiralty brass
Light gas oil	4	2,020	Admiralty brass
Heavy gas oil	6	3,030	Red brass clad steel
Intermediate reflux	2	1,140	Admiralty brass
Stabilizer overhead	4	2,280	Admiralty brass
Stabilizer bottoms	1	530	Admiralty brass
Fuel oil	8	4,660	Red brass clad steel
Gland oil	2	1,060	Admiralty brass
Gland water	2	1,140	Admiralty brass

● **Decoking equipment.** Coke is removed from the drums by a water jet designed by the Worthington Pump and Machinery Corporation, which cuts the body of coke into pieces small enough to fall into a crusher car. The crusher car breaks the pieces of coke down to a maximum dimension of 5 in. and feeds the sized coke into a sluice. The coke is sluiced with water into a suction pit from which a coke-water slurry is pumped through a 12-in. line to the storage area. In this area the bulk of the coke is separated from the water and is moved to a convenient location for shipping. The water passes through settling basins to allow any coke fines to drop out and is then returned to the unit for reuse.

The decoking water jet is supplied by a centrifugal five-stage volute pump with external interstage passages. An hydraulically balanced rotor was obtained by providing double inlets at the first stage and by placing the remaining four single inlet stages back to back. The double inlet at the first stage also provides a low inlet velocity that permits operation at a low submergence. All impellers are of the enclosed type. A pressure breakdown bushing is provided at the inboard stuffingbox so that both stuffingboxes are under suction pressure. The 4000-rpm 1450-hp turbine drive is supplied with 165 lb, 100 F superheated steam and exhausts to a 26-in. Hg. vacuum provided by a barometric condenser. Two complete pumping units are provided; one will supply 1100 gpm at 1500 lb.; two in parallel will supply 1600 gpm at the same pressure. Electrically powered block valves, situated in the discharge line, operate to prevent a shut-off against the pump. When the main block valve begins to close a smaller bypass valve begins to open to discharge the water back to the suction tank. In reverse the valve operation affords the same protection. From the pump discharge the jet water flows to a manifold at the top of the coke drum.

A 100-ft derrick structure is mounted over each pair of coke drums to support the drilling equipment. Each drilling assembly includes a continuous length of drill stem that is long enough to reach the entire length of the drum and to which the boring and cutting tools can be attached. The drill stem is coupled at the top to a swivel head, which is rotated by an air motor and which can be raised or lowered by a steam winch. An assembly of Chiksan joints form a flexible connection to supply jet water to the swivel head. Block valves have been provided in the jet water lines to each drilling assembly. These valves are closed whenever the drill stem is removed from the drum so that no one would be

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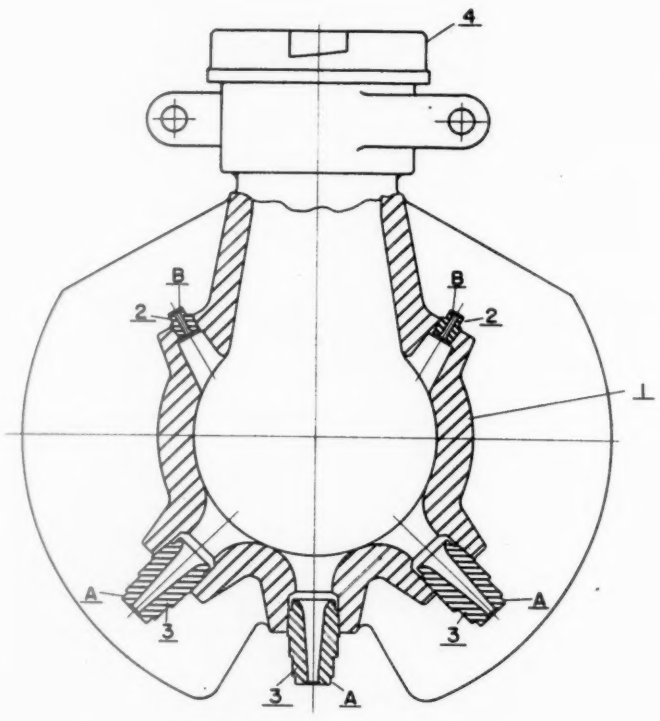

FIG. 2. First boring tool assembly of hydraulic decoking system.

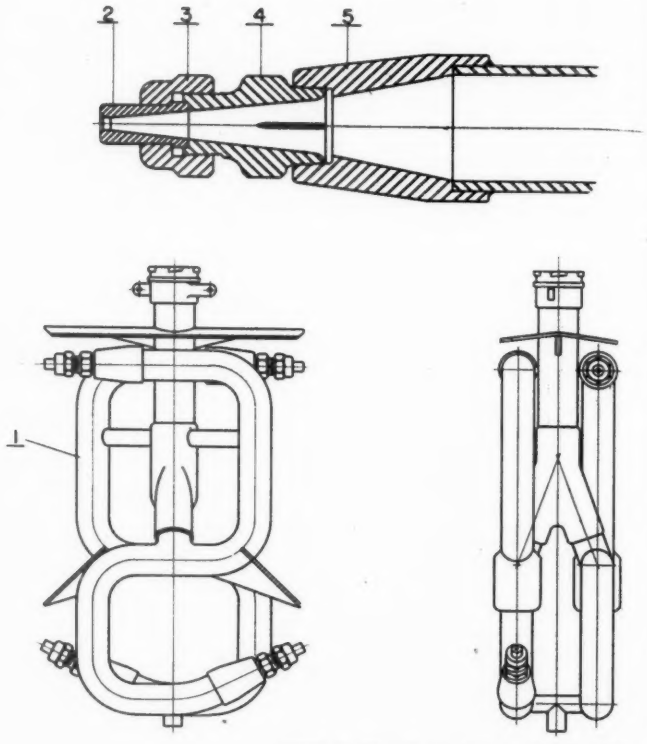

FIG. 3. Final cutting tool assembly of hydraulic decoking system.

injured if the high pressure water were inadvertently turned on.

The cutting devices for removing coke are a boring tool, a reaming tool, and a cutting tool. The boring head, which is illustrated in Fig. 2, is essentially a round ball about 10 in. in diameter, which is tapped for water nozzles. One ½-in. nozzle is situated in the bottom to direct a jet straight downward, and four ⅜-in. jets are symmetrically arranged about it to direct the water downward at about 45 deg. from the vertical. Two ⅛-in. jets are directed upward to keep any coke fines from settling on top of the tool and stopping its rotation.

For reaming, the same tool is used, except that the bottom jet is removed and plugged off, and the four ⅜-in. nozzles are replaced with ½-in. nozzles.

The cutting tool shown in Fig. 3 is an hydraulically designed assembly that splits the single stream of water in the drill stem into four jet streams. Two streams are projected horizontally at the top of the tool and the other two at the bottom are directed upward at such an angle that they cut the same plane as the horizontal jets at the surface of the coke drum, or at a distance of 8½ ft from the axis of the drum. The nozzle tips in this tool are replaceable and at the present time ⅝-in. tips are used in the bottom nozzles, whereas 7/16-in. tips are used in the top.

The crusher car, which grinds the coke to a size easily pumpable by the coke pump, consists of an 11 ft by 14 ft hopper that feeds the coke to two 2-ft diam. by 5-ft long toothed rolls spaced 5 in. apart. The rolls are driven by a 40-hp motor. The crusher car is mounted on wheels and a track so that it can be positioned beneath any of the four drums. A "grizzly," fabricated of 1-in. by 8-in. plate, has been added near the top of the hopper to keep any large chunks from bridging over the crusher rolls or damaging them by impact.

The crushed coke and the water from the jets pass between the rolls into a sluice that leads to a coke sump. Additional sluice water is added to the ditch as needed to keep the coke and water from piling up under the crusher car. An Allen-Sherman-Hoff Hydroseal coke slurry pump, placed in a pit adjoining the coke sump, pumps the coke-water slurry through a 12-in. line to the coke storage some 2500 ft from the pump. The pump derives its name from the clean water supplied to the case to seal the impeller. This water also serves to flush grit away from the close clearance area between the impeller shrouds, shaft, and suction eye and the rubber lining provided in that area. The speed of rotation of the pump can be varied by means of an adjustable sheave on the motor and three sizes of sheaves on the pump. At 600 rpm the pump will discharge about 3000 gpm of water over a coke outlet some 38 ft above its suction nozzle through 2500 ft of 12-in. line.

Special hydraulic lift cars were designed to raise and lower the heavy bottom heads of the coke drums. Had only one car been provided, the track system would have been needlessly complicated to permit moving one car past the other. This complication was avoided by providing cars to be placed on the single track on both sides of the crusher car. Also, with two cars, two drum heads can be worked on at the same time. The hydraulic lifts operate on 90-lb water and are individually capable of supporting the bottom head plus the drum height of water.

This brief description of the principal process equipment should serve to clarify the following discussion of the unit operation. Additional equipment description will be included in the discussion.

● **Operation of the unit. Feed introduction.** Reduced crude is charged to the bubble tower by Quimby screw-type charge pumps under control of a flow-controller that regulates the rate by positioning a bypass valve between the pump discharge and suction. The reduced crude is preheated by exchange successively with the light gas oil product, the medium gas oil product, the intermediate reflux stream, and the heavy gas oil product before entering the bubble tower at two points, at the top baffle tray or five baffle trays above the cracked vapor inlet and at the second baffle tray from the bottom or two baffle trays below the cracked vapor inlet. With a preheat level of only 450 F the feed serves as a hot reflux and care must be exercised to avoid transferring so much heat to the tower bottom product, through a contact with the cracked vapors (the sole source of fractionating heat), as to impair the fractionation of the tower. This condition is avoided by temperature controlling the flow of reduced crude to the top inlet so as to maintain a constant temperature on the bottom bubble tray. The excess feed is diverted by a pressure controller to the lower inlet. Any feed thus diverted also serves to subcool the tower bottom and thereby reduces the tendency to form coke in this reservoir.

● **Heating.** Both furnace charge pumps take suction off the tower bottom to de-

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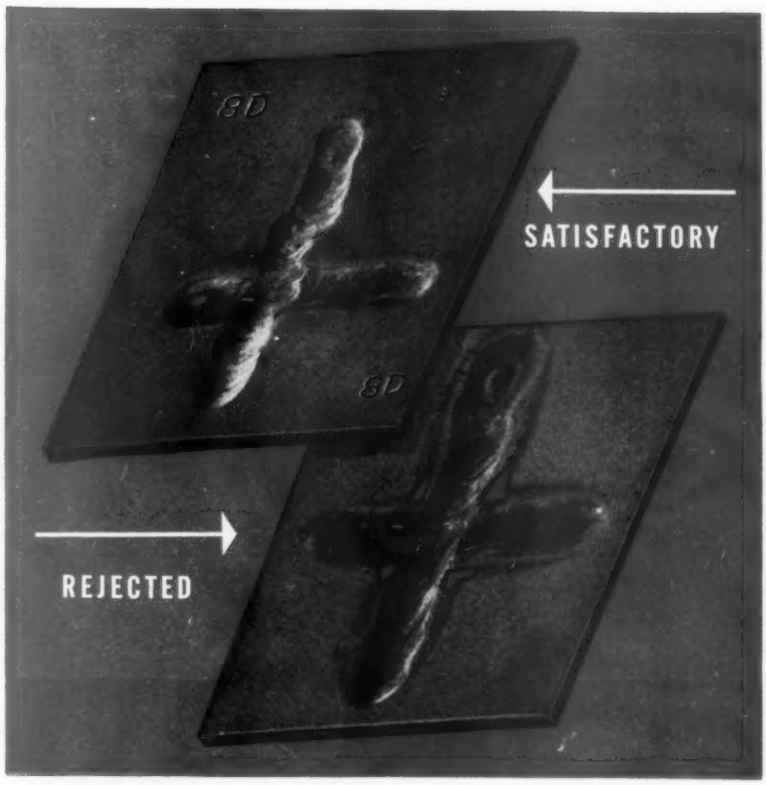
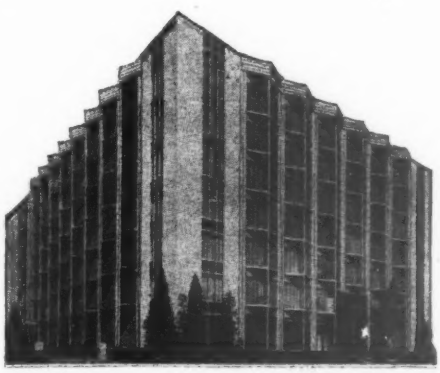


Results of corrosion tests on cross-welded plates of AISI Type 316 stainless steels from two heats of similar chemical analyses.



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liver the charge to the four parallel coils in each furnace. The radiant section of each furnace is divided into two combustion chambers containing two of the coils. The charge flow is rate controlled to each half of the furnace and the fires in each combustion chamber are separately controlled to maintain a constant temperature at the combined outlet of each pair of coils. The two temperature controlled outlets from each furnace join in a furnace transfer line that discharges into one of the two coke drums allocated to each furnace.

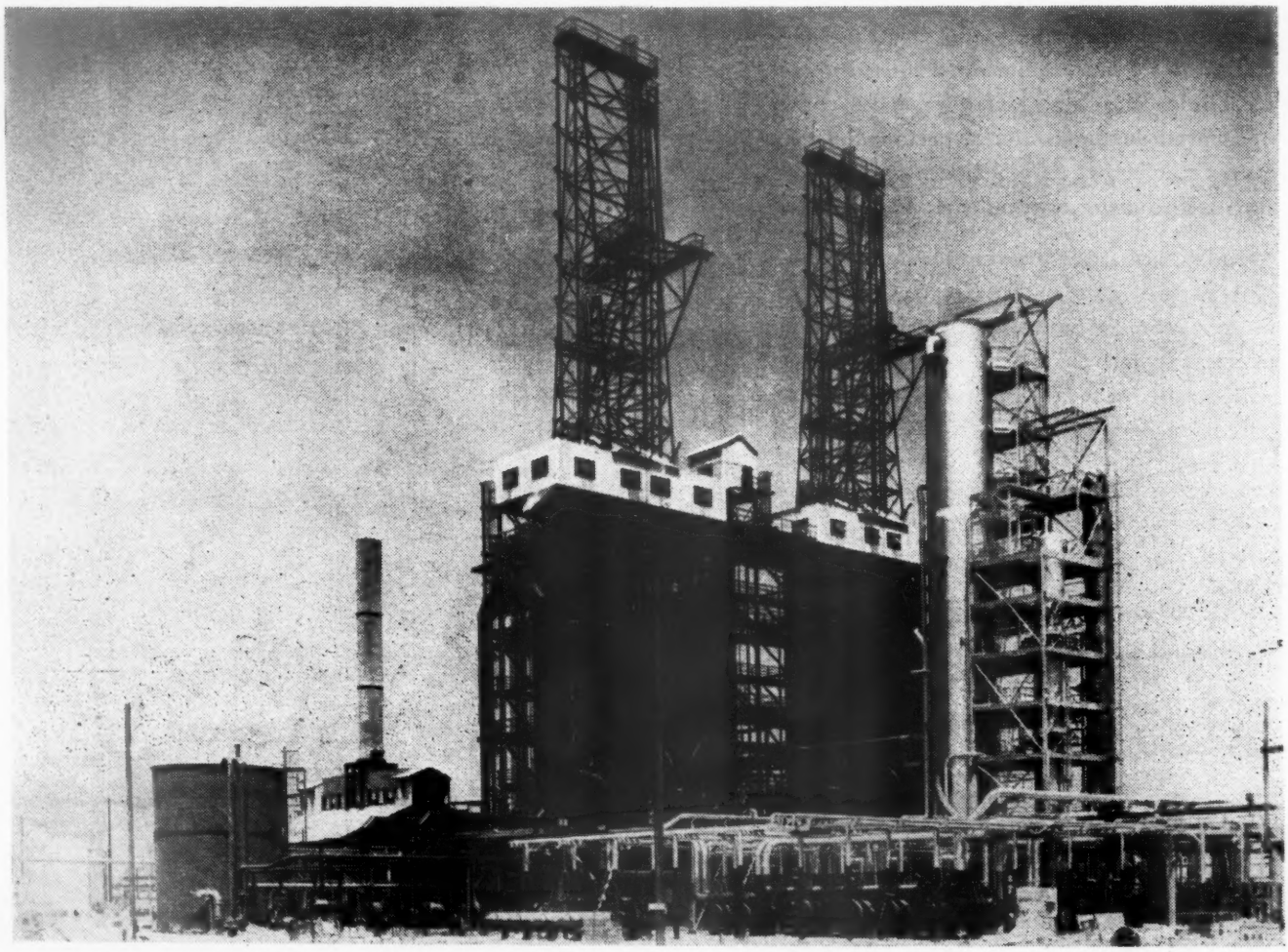
● **Coking.** The heated mixture of vapor and liquid from the furnace enters the bottom of the coke drum. As only vapors can pass out the top of the drum, any liquid must remain in the drum until it is cracked to vapors and coke. As coke is deposited the incoming liquid and vapor must flow through the coke bed and through or into the liquid on top of the coke. With vapors and liquid continually flowing through the coking region, the coke deposited is of a highly porous nature, which facilitates subsequent handling and contributes to the quality of the product. Each drum remains on the line for 24 hr during which time approximately 250 tons are therein deposited.

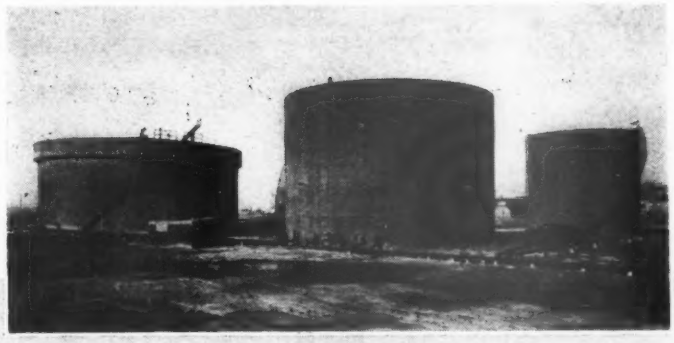
● **Fractionation.** The vapors from the two drums currently in simultaneous operation enter the bubble tower between the fifth and sixth baffle trays, numbering from the top. As previously mentioned, this stream supplies the sole source of fractionating heat to the tower. The top temperature of the tower is controlled, by means of vaporizing reflux, to pass the gasoline and lighter streams overhead. A portion of the downflow induced by the top reflux is removed from the tenth bubble tray, steam stripped, and delivered to storage, after heat exchange and cooling, as light gas oil. The remaining downflow is augmented at the fifteenth bubble tray by an intermediate reflux stream and by the additional reflux thereby induced. To handle this additional flow the tower is enlarged at the fifteenth tray from 11 ft to 12 ft 6 in. in diameter. The intermediate reflux is removed from the twentieth bubble tray to be cooled by heat exchange with the fresh feed, by supplying heat to the debutanizer reboiler, and by exchange with cooling water if necessary. The intermediate reflux returned to fifteenth tray is rate controlled. Should it be desirable to reduce the down flow on the lower bubble trays some intermediate reflux can be manually controlled to the first baffle tray. As an added means of reducing the coking tendency in the bottom two baffle trays and the tower bottom reservoir, provision has been made to manually control some of the reflux to the seventh baffle tray if needed. The intermediate reflux draw is also used to remove the medium gas oil product, which is stripped and cooled. The heavy gas oil, which is also stripped and cooled, is withdrawn from the twenty-fourth bubble tray.

The preheated fresh feed is added to the first baffle tray as required to maintain a constant temperature on the twenty-fifth or bottom bubble tray, the remaining feed being diverted to the seventh baffle tray. The tower bottoms, which include the fresh feed and recycle, are rate controlled to the furnaces. The lowest sidedraw is withdrawn at the rate required to maintain the tower bottom level. Under this arrangement, with a constant 20,000 bbl per day charge to the furnaces, the recycle rate is automatically determined as the difference between the fresh feed rate and the total furnace charge.

The bubble tower overhead is cooled and condensed in the cooling tower and is separated into gas and gasoline in the reflux accumulator. The gas flows through a back pressure controller to the refinery central compressor station where it is compressed to the central absorption plant pressure. This controller sets the pressure for the entire system so that the pressure on the coke drums and the bubble tower are but 2-4 lb higher than the 52 lb held on the bubble tower reflux accumulator. The resulting

Process area shows four coke drums, two derricks, and fractionating equipment.





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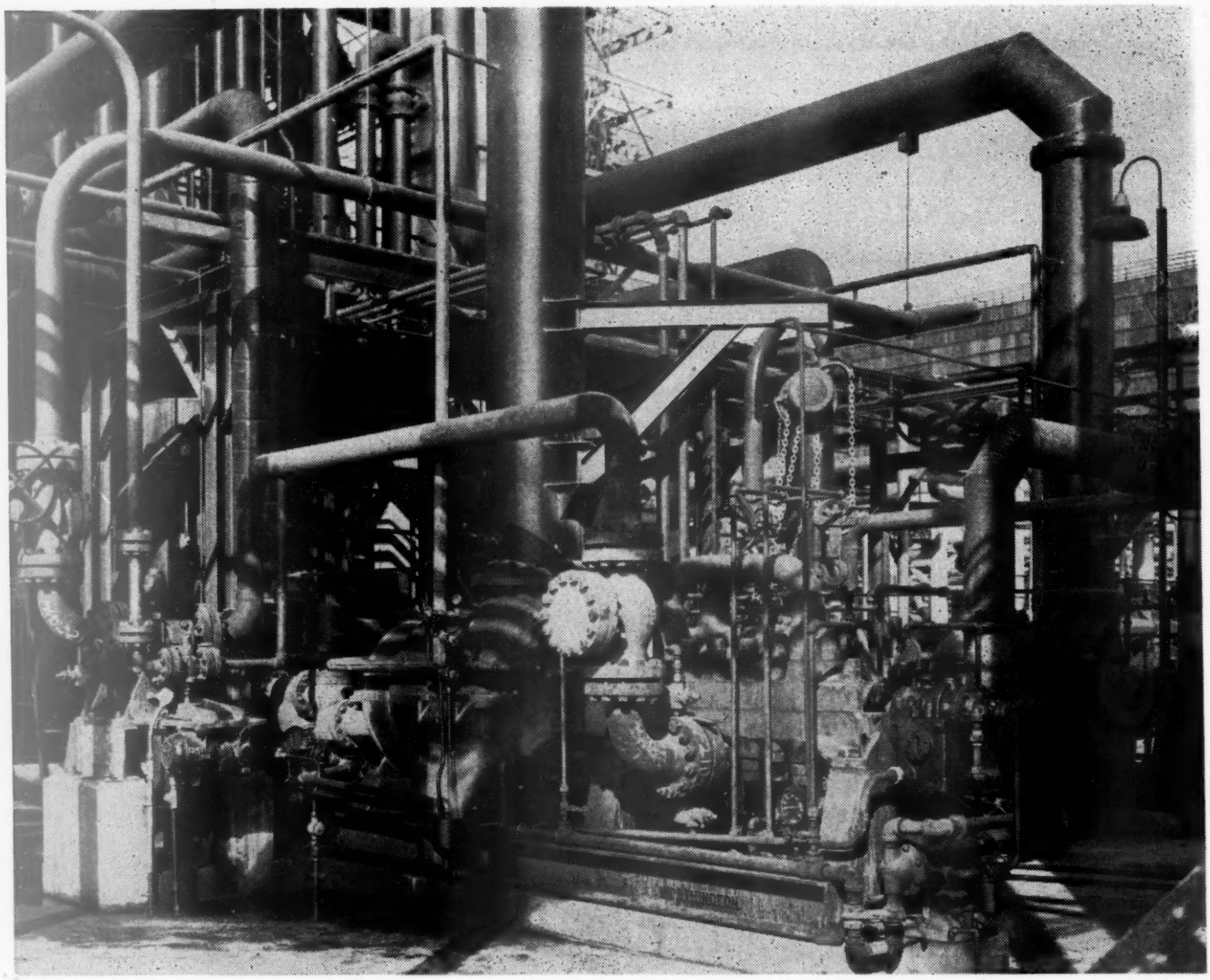

Jet water pump and turbine with automatic bypass valve shown at left.

pressure at the furnace outlet rides at about 75 lb.

The stripping and coke drum cooling steam are also condensed in the overhead condensers and removed from the accumulator through a bottom boot. The hydrogen sulphide content is so high that this water must be steam stripped in the refinery central deodorizer before it can be delivered to sewer.

Gasoline reflux is pumped back to the top of the bubble tower under control of a temperature element situated in the vapor space above bubble tray No. 2. The net gasoline make is charged to the debutanizer after heat exchange with the debutanized gasoline. The raw B-B is delivered to raw B-B storage for ultimate alkylation plant feed and the uncondensed vapors to the central gas plant under its own pressure. For more precise control the tower pressure is maintained by a vapor line regulator. In order to insure a steady reflux pressure and thereby smooth out reflux flow, the accumulator pressure too is controlled within narrow limits by the use of a repressuring controller that bypasses vapors around the condensers to maintain the accumulator pressure, and a depressuring controller that relieves the excess pressure to the gas plant.

Reboil heat is obtained from the intermediate reflux stream. To reduce the tendency to polymerize the cracked gasoline, it was decided to hold the temperature of the heating stream to 600 F or below. As this stream runs close to 700 F, it is first passed through the first of its four heat exchangers and is satisfactorily cooled by exchange with the fresh feed. A temperature element on the thirty-fourth tray controls the quantity of heating oil to the reboiler by positioning a three-way control valve. After passing through the reboiler, or bypassing it, the intermediate reflux stream is further heat exchanged against the fresh feed in the remaining three exchangers and cooled if necessary before it is returned to the bubble tower.

● **Decoking. Drum cycle.** Operation of the coke drums requires that the furnace transfer line product be switched from one drum to another whenever a drum is filled with coke to the desired outage. At normal feed rates each drum is on stream coking for 24 hr and is off stream for cooling, decoking, and heating up for the same period. The drum switches are so timed that one of each pair of drums comes off stream every 12 hr. Under normal conditions the cycle for one drum is about as follows:

Log of a typical drum cycle.

Elapsed time, hr.	Operation
0.0	Switch oil stream to clean drum. Steam full drum to bubble tower.
0.5	Stop steam to bubble tower, steam to blowdown.
0.75	Stop steaming, start cooling with water.
2.75	Stop cooling, start draining water, blinding and unheading.
4.0	Start decoking.
11.0	Finish decoking, start heading up and removing blinds.
12.5	Steam test
13.0	Finish steam test.
18.0	Start heating.
24.0	Switch in oil stream from full drum.
48.0	Switch oil stream to clean drum.

The transfer line from each furnace is connected to a three-way switch valve that diverts the transfer line product to either coke drum or through a bypass line to the bubble tower. Before switching the oil from one drum to another, the empty drum is preheated by forcing some vapors from the on-stream drum into the top and pumping the condensate from the bottom of the drum into the bubble tower.

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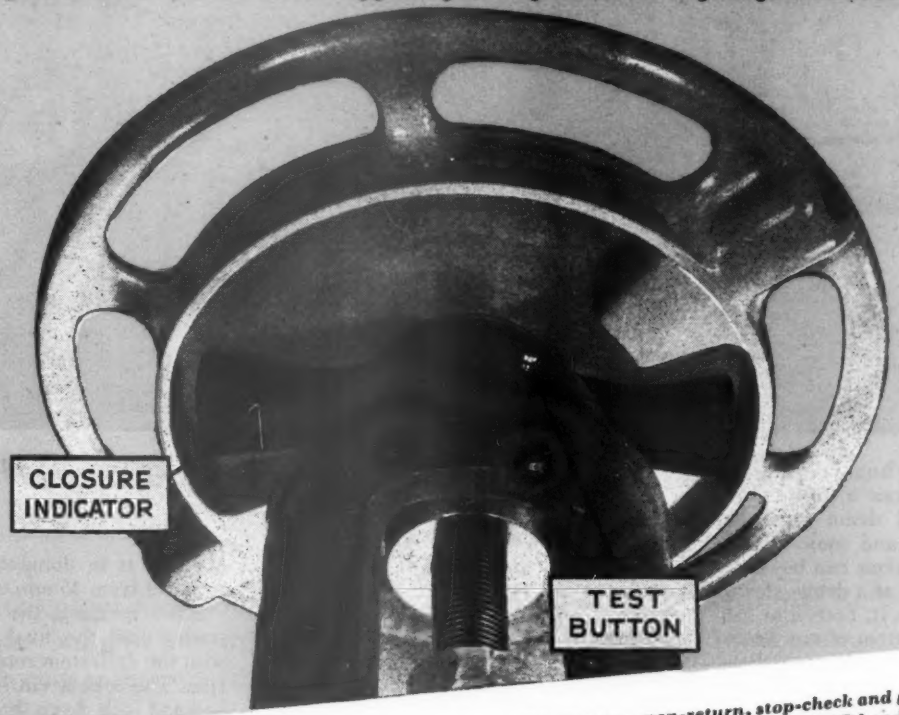

Notice—

- how the two heavy lugs, cast integrally with the wheel at 180°, strike simultaneous hammer-blows on the cross arm attached to the stem —making a positive shut-off.
- ample strength for any operating emergency.
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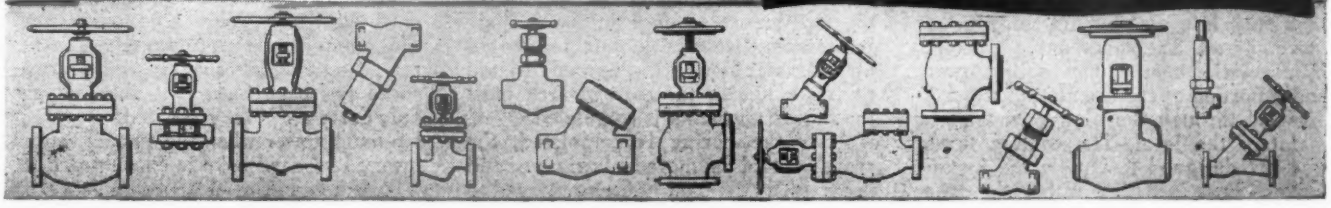
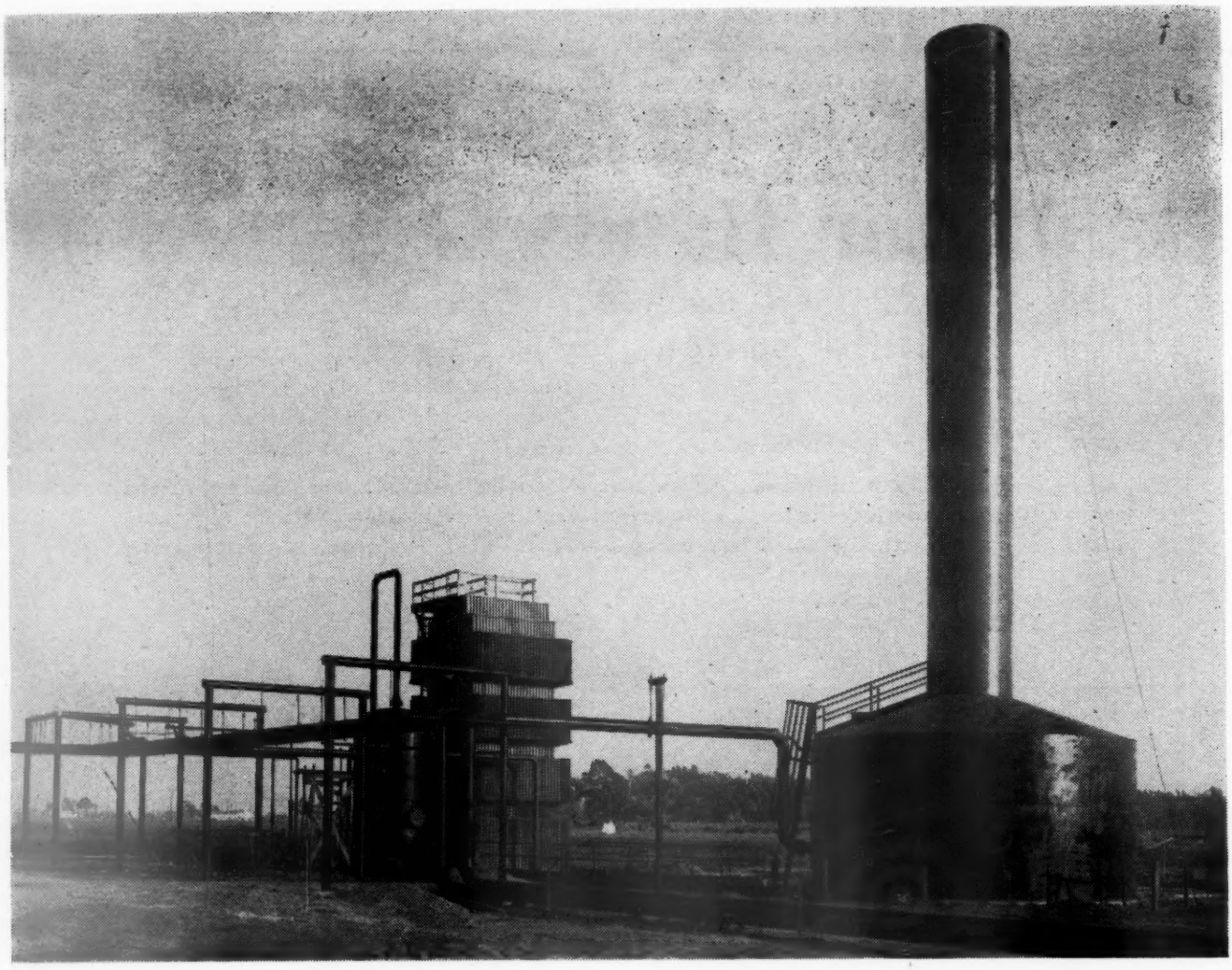




Blowdown system of the Torrance delayed coking unit.

● **Blowing down.** Whenever the oil stream is switched from a full to an empty drum, the full drum must be purged of volatile oils and cooled down so that decoking operations can be started. After switching out of a drum, steam is immediately cut into it, both into the transfer line to the bottom of the drum and into a steam ring just above the bottom cone. The full drum is steamed to the bubble tower for 30 min: and is then depressured to the blowndown system. After 15 min. steaming to the blowdown, the steam is cut out and water pumped to the steam ring.

This cooling produces considerable steam that must be handled in the blowdown system situated about 2000 ft from the unit area. The blowdown line exhausts into a small tank about 6 ft below a water level maintained by a continuous circulation through the tank. The circulation is sufficient to remove the superheat of the steam and to condense any oil vapors. Some saturated steam is vented from an 80-in. stack mounted on top of the tank. The overflow from the tank runs into a skimming sump to remove any oil. The sump water is cooled by circulation over a 2-bay cooling tower, and a portion of the circulating water is diverted through the blowdown tank to maintain the level. The cooling tower was not designed to handle the instantaneous heat load, but rather the average heat load, the volume of water in the system acting as a flywheel or heat reservoir.

When the coke bed has been cooled to 200-300 F the cooling water is cut out and the drum drained. It is then ready for the decoking crew to start blinding off, opening the heads, and removing the coke.

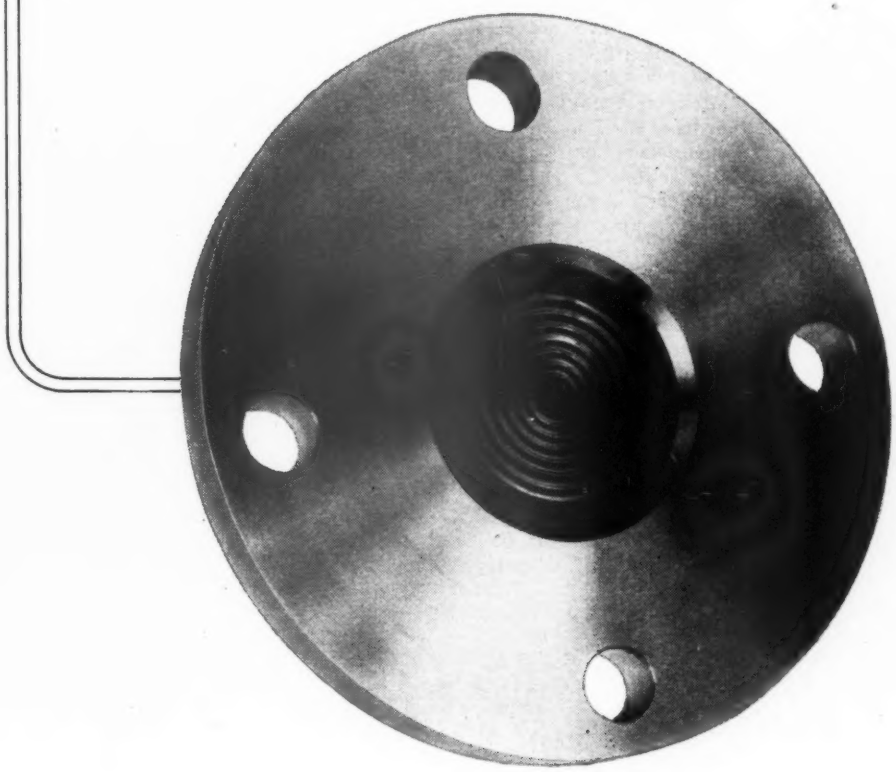
● **Operation of the decoking equipment.** After a drum is cooled and drained the lines leading to the drum are blinded and the manheads removed. With the crusher car positioned under the drum, the boring is begun with the stem rotating at about 8-10 rpm. The drill is lowered as fast as possible without allowing the boring tool to actually touch the coke bed. Normally about 15 min. are required for the high velocity water to cut a hole through the coke. Some water leaks through the bed while drilling, but most of it is held up in the drum until the tool breaks through at the bottom. In the meantime the coke pump is started up and water alone is discharged through the coke line to the storage area until the boring operation is completed.

After the boring is completed, the reaming tool is moved slowly up and down until the hole has been enlarged to about 6 ft in diameter. This operation requires from 45 min. to 2 hr.

After reaming, the cutting tool is installed and the final cutting is begun with the drill stem rotating at about 5-10 rpm. The coke is cut from the top of the bed and falls down through the hole into the crusher car. It is usual to lower the tool about 8 in. at a time and rotate it for 2-3 min. before again lowering. Every 5-10 ft the jet is shut off and the drum is inspected for cleanliness. It has been found necessary to remove the coke completely on the way down, for any ledges left behind for later removal will frequently fall into the crusher car and plug up the top grating or will bridge across the bottom of the drum.

Occasionally the coke is cut from the drum at such a rate that the coke pump, operating at medium speed, will not handle it. When this occurs the cutting rate is lowered by reducing the depth of cut until the excess coke is pumped away. The pump can be set to pump at a faster rate, but it is felt that a good average speed has been fixed that does not unduly delay the coking and does not pump too much water when the cutting rate is lowered as hard coke is encountered. It is also possible to cut coke so fast that

A SLICK ANSWER TO A STICKY QUESTION!



WHEN you've got an open tankful of slurries, soap, paper pulp, or any other viscous or corrosive liquids containing solids, it's a problem to measure the liquid level accurately. But, it's no problem with the new Taylor 229R Liquid Level Transmitter.

A simple, highly responsive device built on the force-balance principle, it can't clog up because there's no place for a "traffic jam" to start. There's no chance of frictional error either because there are no levers or cams. The pressure of the head of liquid is exerted against a 3-inch stainless steel diaphragm attached to a stainless steel flange and is balanced by an equivalent air pressure in back of the diaphragm. This back pressure is transmitted to a Taylor indicating, recording or controlling receiver which can be located anywhere you want it for a steadily dependable record of liquid level.

For full details write for Bulletin 98069 or ask your Taylor Field Engineer.

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IN HOME AND INDUSTRY

resulting large chunks cannot be handled by the crusher. With the proper care in cutting the chunks can be eliminated, but it is easily possible to cut the coke faster than the crusher can handle it. The 18-in. grating added 2 ft from the top of the crusher car hopper protects the rolls from damage should large chunks inadvertently fall from the drum. It also retains the chunks where they can be manually broken up. When the coke is moderately hard the time required from the beginning of the boring until the drum is completely clean averages about 6½ hr. This corresponds to an overall coke removal rate of about 0.7 ton per min. Considering the time consumed in changing tools, inspecting the drum, etc., the maximum coke removal rate is probably in excess of one ton per minute.

When the drum is completely clean the transfer line and condensate line are inspected and cleaned if necessary, the steam out valves are blasted with steam and the drum heads are replaced. After removing blinds and steam testing the drum is ready for heating prior to another 24 hours of coking service.

● **Operations in the coke storage area.** The coke-water slurry discharges onto an inclined chute the bottom of which is made of 6 mesh steel screen. The majority of the coke rolls down the screen while the water, together with all materials below about 20 mesh, passes through the screen and down a solid chute to a temporary settling pond, which is retained by a coke dike. A number of pipes are embedded in the dike and the water overflows through the pipes into a drainage ditch that leads to the secondary settling basin. The coke that rolls off the screen is moved by a bulldozer into piles from which it is loaded onto trucks.

This arrangement for separating the water from the coke is temporary and was devised after our original efforts along the following lines were unsuccessful. Originally it was planned that the coke would be piled in a circular dike of such proportions that the coke and water from one drum cleanout would be retained behind the dike. It was expected that the water would filter off promptly to permit moving the coke out of the way with a bulldozer to make room for the next cleanout; however, the quantity of water (Ca 1,500,000 gal.) and coke from one cleanout was so great that we had difficulty building a dike large enough to contain it. Furthermore, the fines content of the coke plugged the pores of the dike so that 3-4 days were required for the water to filter out.

A permanent coke-water separating installation is under consideraiton that consists of a screen chute, a series of hoppers that can be used for loading trucks, and a primary settling basin that can be easily cleaned of coke.

Presently, a loading crane is used to move the coke from the pile to the hauling trucks. The load is measured by weighing and delivered to the Great Lakes Carbon Corporation.

To return to the water cycle, two 500,000 gal. secondary settling basins have been provided to permit the deposit removal from one while the other is in settling service. These basins are situated at each end of a 3,000,000-gal. storage pond into which they overflow through submerged pipes. The pipes are so placed as to leave both the settled and floating fines in the secondary settling basin. The relatively clean water from the storage pond is returned to a surge tank in the unit area by two vertical deep-well pumps. The jet pumps, the drum cooling water pumps, the sluice water, and the automatic make-up water to the coke-slurry pump suction pit are all supplied from the surge tank.

Make-up water is supplied to the system from the Los Angeles Metropolitan Aqueduct System, or from the refinery wells. Tentative plans have been made to utilize the effluent water from the refinery waste water system for this purpose.

● **Operating conditions and yields.** Presently the unit is charged with 700 SSF/122 straight run residuum from Wilmington crude at a rate of 15,000 bbl per day, which effects a recycle to fresh feed ratio of 0.33/1. The 20,000 bbl per day charged to the furnaces are heated to 920 F.

The bubble tower is operated to produce gasoline with an end-point of 380 F, light gas oil with an endpoint of 650 F, and medium gas oil as necessary to maintain a level in the bubble tower bottom reservoir. No heavy gas oil is being removed. In the stripper tower the gas oils are stripped to a flash point that makes them suitable for use as cutter stock, although at the present time the light gas oil is used as TCC charge. Tests are being made to test the feasibility of also using the heavier gas oil in TCC charge.

Under the above operating conditions the following yields were obtained. Additional operating conditions have also been tabulated.

Operating conditions and yields.

Operating conditions	
Reduced crude charge, bbl. per day	15,000
Furnace charge, bbl. per day	20,000
Recycle/fresh feed	0.33
Temperatures—Furnace outlet, °F.	920
Drum inlet., °F.	900
Drum outlet., °F.	830
Drum pressure, lb.	56
Viscosity of fresh feed, SSF/122	700
Yields	
Total gas, wt. per cent	14.0
Raw B-B, liq. vol. per cent	0.8
Debutanized gasoline, liq. vol. per cent	22.5
Light gas oil, liq. vol. per cent	36.5
Medium gas oil, liq. vol. per cent	16.7
Coke (by difference), wt. per cent	19.1

It is rather difficult to determine coke yields accurately. Because of varying coke density, measurements by coke drum levels do not appear to be too reliable. The above difference method includes in the coke yield any gains or losses in the process. The yields can be roughly checked by means of the weighed haulings, which approximate 500 tons per day.

It is likewise difficult to obtain representative coke samples. Samples obtained show approximately 0.25 per cent ash, 9 per cent volatile matter, and a screen analysis satisfactory for its intended use.

As would be expected with this type of process, the high sulphur Wilmington residuum charge yields a gasoline with an appreciable sulphur content. This sulphur content and the olefinic content of the gasoline are sufficient to require sweetening and rerunning. M. M. clear octane numbers in the neighborhood of 70 are obtained with an octane spread of 8 or better. Lead susceptibility is fair and commensurate with the sulphur content.

Because of the desulphurizing characteristic of the TCC process, the coker gas oils have proved to be quite satisfactory as TCC charge stock despite their high sulphur contents. The 650 F endpoint light coker gas oil, when charged to the TCC units (bead catalyst) with a 1:1 recycle ratio, yielded 41 per cent of 400 F endpoint debutanized gasoline. Furthermore, an octane level of 79 M. M. clear and an octane spread of 10-12 points make this operation look quite attractive.

The low raw B-B yield is a result of the large gas yield from the bubble tower reflux accumulator, which carries with it the bulk of the C-4 production. The total gas yield amounts to 8000-9000 M cu ft a day. The dry gas after absorption amounts to some 7000 M. cu ft a day, which is just double the requirements at the coking unit furnaces. The excess 3500 M. cu ft a day represents an appreciable contribution to the other refinery units' demands.

● **Effect of operating variables.** Our operating time has been far too short to establish the effects of operating variables. Nevertheless, some indication of their effect has been obtained. Increased viscosity of the charge appears to shift the gasoline and gas oil production slightly toward more gas and coke. Furnace outlet temperature changes through the range 910-920 F also had little effect on gas and gasoline yields; however, gas oil production increased with a decrease in coke yield. Reducing the recycle ratio shifted the yields from coke to the gas oil and lighter products.

From the above indications it appears that any benefit that may be derived from a high removal of straight run gas oil from the charge is not appreciably invalidated by lowered coker yields; yields may be varied extensively by manipulation of the recycle ratio; and higher furnace outlet temperatures may be feasible.

● **Unit flexibility.** The unit is quite flexible in that it can be used either as a coker, a visbreaker, or any combination of these two. For any operation other than full coking a higher inlet to the coke drum would be used. The rate of residuum withdrawal from the bottom of the drum would determine the amount of coking permitted. In a full visbreaking operation, it is also possible to charge the fresh feed directly to the furnace along with the recycle. Under this arrangement, the residuum would be removed from the bubble tower bottom and the recycle from the bottom draw. ★ ★ ★

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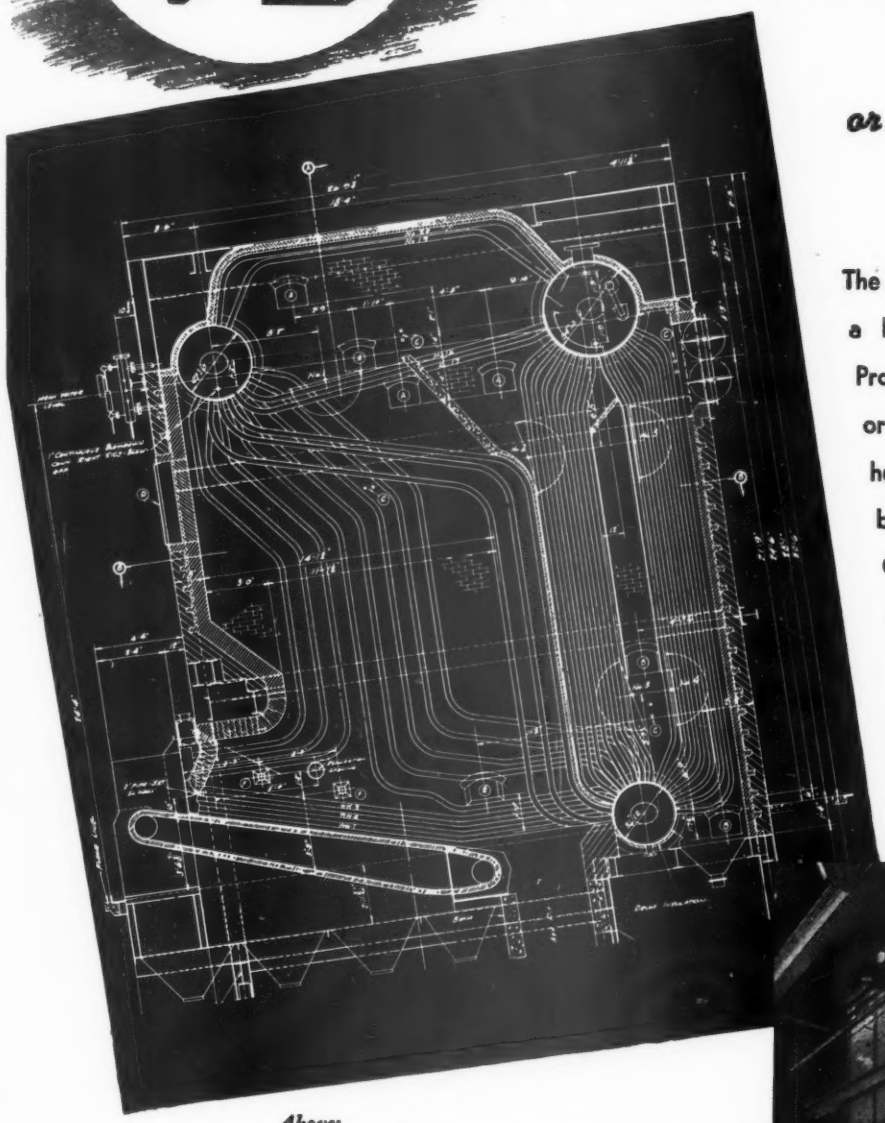

Above:
This 90,000 lbs. steam per hour unit, designed for 475 lbs. pressure, serves the Mansfield Tire & Rubber Co., Mansfield, Ohio.

Right:
Two 515 H.P. units installed in Brown-Forman Distillers Corporation, Louisville, Ky. Plant.

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Use of variable capacity plunger pumps with electric motors for pipe lines*

By **B. F. THOMPSON,** Public Service Company of Oklahoma

DEVELOPMENT of a practicable variable stroke reciprocating pump by a prominent pump manufacturer has placed a valuable new tool in the hands of the engineer designing pipe line pumping stations, particularly if his design contemplates the use of electric motors of automatic operation. To us in the electric industry this is of particular interest, for the constant speed of electric motors has in the past limited the flexibility of electrically operated pumping stations and so has been an item that shows to our disadvantage in comparisons with competitive power. The new pump completely removes this disadvantage and through its possibility of automatic operation actually adds to the flexibility of the pipe line system.

The pump, the Aldrich-Goff variable stroke pump, is essentially a plunger pump with a method of varying the stroke built in so that when operated at constant speed any range of pump deliveries from zero to full capacity may be obtained. It operates at the high mechanical efficiencies of plunger pumps over a wide range of pressures and deliveries.

Essentially it is a vertical triplex plunger pump. The crankshaft is connected to the plunger connecting rods through an extra link and extra crosshead. This extra crosshead is curved and can be tilted back and forth by a hydraulic piston or handwheel, the amount of tilt determining how far the plungers travel. Through varying this tilt any plunger movement from zero to the full pump stroke may be obtained, variation being smooth and continuous.

For most applications automatic varying of plunger travel is indicated, and this may be accomplished to fit almost any given set of conditions by applying a usually simple set of controls to the pump mechanism. Oil pressure to operate the hydraulic piston is provided by the lubricating oil pump supplying high pressure lubrication to the pump bearings, which is made oversize especially for this purpose. The high pressure oil is admitted to either end of the piston through a four-way valve, which may be opened or closed by the control device. An ordinary diaphragm pressure regulator can serve very well to move the control valve, and in many cases can be used to provide the control directly, but usually in pipe line practice it will be found more satisfactory to use an auxiliary air source to obtain more sensitive operation. Through use of this type control very close regulation of output or pressure may be obtained. About 2 per cent maximum variation of the pressure or delivery desired is entirely possible and has been obtained in some installations.

Efficiencies of operation are high, varying from 85 per cent or better at full plunger stroke to about 80 per cent at half stroke, and falling to only 65 per cent at 25 per cent of full stroke. In combination with an electric motor, overall efficiencies of 65 per cent at half load to 78 per cent at full load will be reached.

It would seem that this pump combines the best features of the centrifugal pump (flexibility of capacity and constant pressure) with the best features of the reciprocating pump (high operating efficiencies and low maintenance expense) without acquiring their disadvantages.

At present the variable stroke pump is built in six different sizes, ranging from 2-in. to 6-in. stroke and from 10 hp to 100 hp maximum load. Plunger sizes are varied to accommodate the pressure desired, which can run as high as 15,000 psi. For economic reasons about 500 psi is about as low a pressure as would generally be used. The largest unit will deliver a maximum of 8500 bbl per day at 565-lb pressure.

Although we have spoken of this as a new pump, it has been in actual use for a number of years. On pipe lines the oldest installation is now about six years old and is still in operation. This is on the Magnolia Pipe Line Company's butane line from the East Texas field to the Gulf Coast. This 186-mile line has two pumping stations at each of which is installed a 75-hp variable stroke pump, designed to operate at a minimum suction pressure of 50 lb and a discharge pressure of 850 lb. Plunger diameter is 3¼ in. and the stroke may be varied from 0 to 6 in. Operating at any capacity from 0 to the full flow of 4300 bbl per day, the pumps always run at 200 spm.

Several factors combined to influence the choice of pumps on this line: Centrifugal pumps would have operated at only 66 per cent efficiency, requiring a 125-hp prime mover, as against the 90 per cent efficiency and 75-hp motor required by the variable stroke pumps chosen. In addition, due to previous experience the operators anticipated trouble in maintaining the pump packing when handling high pressure butane. Reciprocating plunger type pumps appeared to be the most desirable from the standpoint of mechanical efficiency, as well as for the control of the stuffing-boxes and for making adjustments during operation, but the normal type of reciprocating pumps were not so flexible as desired. Mechanical speed changing devices installed between the pumps and prime movers would give a variable capacity of 52½ per cent. Engine driven pumps with an overriding governor control permitted 60 per cent speed variation of the engine and pump capacity. Because of the larger variation possible with the variable stroke pumps and the possibility of automatic control governed by the operation of the initial station, they were chosen as the best solution to the problem.

Automatic controls actually installed are such that the line discharges directly into a still at its terminus, and its entire operation is under the control of the still operator who can vary the flow in the line by means of his valves and flow controls. The pumps at Kilgore, 186 miles away, and at the intermediate station, change their output within a few seconds after the still operator makes any change at Beaumont. Thus, these pumps are still charging pumps though situated 180 miles from the still.

A record of several years operation has shown excellent pump reliability and only minor maintenance and repair required. During this period monthly deliveries and average pressures pumped varied over an approximate range of 1.7 to 1, and kwhr required varied over a range of 1.6 to 1. In other words, cutting line capacity in half reduced efficiency of operation less than 10 per cent.

Another installation is one on a gasoline pipe line of Socony-Vacuum in Brock, Nebraska. Two 6-in. variable stroke pumps, each having a maximum capacity of 4750 bbl per day at 1000-lb working pressure have been in this station since 1941. Speed of these pumps is 225 rpm, which means 675 pumping strokes per minute.

The station is electric driven; 100-hp, three-phase, 2200-volt motors are used. The main line suction and discharge pressures, at the station, control the capacity of the pumps. The speed is always constant. Two recording pres-

*Presented at 18th annual conference of Petroleum Electric Power Association, Tulsa, Oklahoma, December 4, 1946.

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sure controllers are used and each is set for the pressure desired. The discharge pressure is normally set at 1000 psi, and the suction pressure at approximately 50 psi. If the discharge pressure tends to rise, due to any manipulations of the line or station on the system, the pressure regulator will short stroke the pumps, causing them to have a smaller throughput.

Conversely, if the discharge pressure falls, the pressure controller will tend to increase the length of stroke, thus giving a higher throughput. If the suction pressure increases, the reverse is true and the pump will tend to increase its stroke and throughput in order to draw down the suction pressure. If the suction pressure tends to fall, the reverse of the above action takes place. The pump is, therefore, under full automatic control at all times for any condition of pipe-line pressures or capacities within the designed limits, and this is all done by the use of two pressure controllers. This installation is so arranged that if the instrument air pressure fails, the pumps will go to zero stroke.

The station on the line immediately preceding this station contains motor-driven centrifugal pumps. Actual power consumption at both stations was checked during a given period.

The station containing the variable stroke pumps was handling 9200 bbl per day at 1100-lb discharge and 265-lb suction pressure, whereas the preceding station was handling the same quantity at 1200-lb discharge pressure and 175-lb suction pressure. Reducing these figures to the amount of work done for equal differential pressures showed that the variable stroke plunger pump station would use 119 kwhr, whereas the preceding centrifugal pump station was consuming 174 kwhr, or a total difference of 55 kwhr. The variable stroke plunger pumps were putting out 6.5 lb per hp input, and the centrifugal pumps were putting out 4.5 lb per hp input; or the variable stroke pumps were performing 45 per cent more useful work.

If this 55 kw saving is evaluated at 1 cent per kwhr, the saving amounts to $4800 per year, or a sum of $48,000 in a 10-year period. The station is operated by one man who is relieved once a week by the linewalker in that district. This, I believe, illustrates the possibilities of savings available through the combination of electric power and automatic operation on a pipe line of this character.

We are informed that within the last 60 days three major companies have decided to use variable stroke pumps on new lines: Phillips on a products line from Borger to Denver, Standard of Indiana on a products line from Casper to Denver, The Texas Pipe Line Company on a products line from Horn to Dallas and San Antonio.

At the recent API Chicago convention, H. H. Anderson, as chairman of the API Topical Committee on Pipe Line Technology said: "Higher speed triplex and quintuplex pumps are in use by at least one operator. Prime advantages are compactness and reduction of line surges. New vertical variable stroke pumps are proving popular. By automatic or manual control the plunger stroke of these can be varied from zero to a maximum while the pump is in operation. Their design, in effect combines the flexible volume characteristics of a centrifugal pump with the high mechanical efficiency of the plunger type."

These illustrations show that the variable stroke pump has passed the trial state and can now be regarded as a piece of equipment to be used wherever its unusual features can be utilized to advantage.

It is probably too early to predict the extent to which the variable stroke pump will be utilized in the future by the pipeline industry but at present it would seem that its prime field of application is the main line stations of small to medium sized crude and products lines, leaving the large high capacity lines to the centrifugals, and the very small lines and the gathering lines to the reciprocating pumps.

We would like to state in concluding that little of the material we have presented is original, as we have freely used items from articles by E. A. Koenig, D. H. Stormont, Paul Reed, and L. T. Gibbs. ★★★

A GOOD QUESTION AND A CORRECT ANSWER

QUESTION

How can I stop Electrolytic Corrosion?

ANSWER

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2 PRIMER
3 FIRST HOT COAT
4 SECOND HOT COAT
5 ASBESTOS FELT
6 THIRD HOT COAT

HILL, HUBBELL dielectric steel pipe protection is successful against electrolytic and all other kinds of soil corrosion.

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NEW EQUIPMENT

(1) New thermocouple

According to the manufacturer, Arklay S. Richards Company, Inc., 41 Winchester Street, Newton Highlands 61, Massachusetts, better heat treating can be obtained at reduced cost with its new thermocouple of improved design. Supplied with either No. 8 ga standard chromel alumel or iron constantan element, they can be used with any make pyrometer.

Closer temperature control is obtained by the use of a ⅞-in. O. D. heavy seamless drawn inconel protecting tube, which fits the thermocouple element closely for maximum sensitivity of response, it is stated. This is particularly advantageous on automatic control installations.

Long life is assured by the unusually heavy wall thickness (0.147 in.) of the protecting tube and the 80 per cent nickel, 13 per cent chromium high grade ductile alloy eliminates much porosity and mechanical breakage.

Less time is required for inspection and assembly, for the terminal head is designed so that thermocouple can be quickly inspected without disconnecting leads or using a screw driver. There is therefore no possibility of a wrong reconnection and no interruption of production, it is pointed out. Thermocouple wires also enter the connector without bending even when two hole insulators are employed. This time saving feature is of great advantage to large companies who assemble their own thermocouples. The thermocouple element is easily replaced merely by loosening two screws. High grade ceramic connector body withstands high temperatures indefinitely, eliminating continual renewal of this part on severe applications.

These thermocouples are recommended for all general heat-treating service including neutral salt baths; except sulphurous atmospheres, on which Cat. No. 212 (25 per cent chrome, 20 per cent nickel) protecting tubes should be specified. Outstanding results have been obtained on extensive field tests and the thermocouple is now in production, it is said. Immediate delivery can be made from stock on all standard lengths from 12 in. to 43 in., inclusive in multiples of 6 in.; and 60 in. to 144 in., inclusive, in steps of 12 in.

(2) Burn preparation

Developed for the treatment of first, second, and third degree burns, Morco-Thiazole has proved to be an outstanding preparation, according to users in hospitals and the medical professions. Cod liver oil 65 per cent, the active ingredient, supplies vitamins A and D in sufficient quantities to stimulate rapid rebuilding of epithelium. The inclusion of sulfathiazole 5 per cent, inhibits infection and minimizes the danger of scars and contractures.

The Archer-Taylor Company, 700 North Main Street, Wichita, Kansas, is offering a 2 oz. sample jar to company physicians and first aid stations.

(3) Cable control

In order to provide a lower cost rear-mounted double drum cable control unit for use with "Caterpillar" Diesel D6 and D7 tractors, Caterpillar Tractor Company, Peoria, Illinois, is now producing a new cable control designated as the No. 23.

Designed to develop line pulls ample to meet service requirements imposed by the operation of scrapers, bulldozers, and rippers, the new cable control provides smooth, easy operation with a minimum of adjustments, the manufacturer asserts.

The No. 23 offers all the features of the company's No. 25 rear double drum cable control and the No. 24 single drum, front-mounted control, including the smooth performing multiple disk type clutch that has been a performance feature of "Caterpillar" track-type tractors for years.

(4) Airfoam-generating nozzle

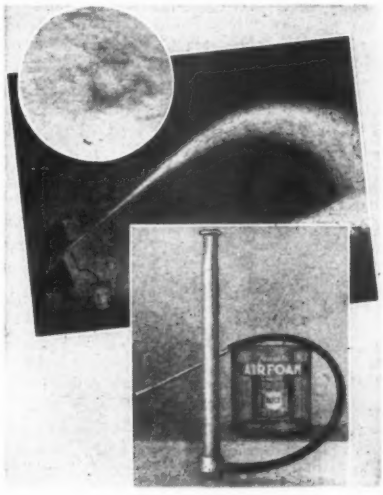
New and novel! The Foamite Airfoam-Generating Nozzle—a strikingly out-of-the ordinary foam-making, fire-fighting nozzle, is only 2½ in. in diameter at the widest part of the barrel. It is made by American-LaFrance-Foamite Corporation of Elmira, New York.

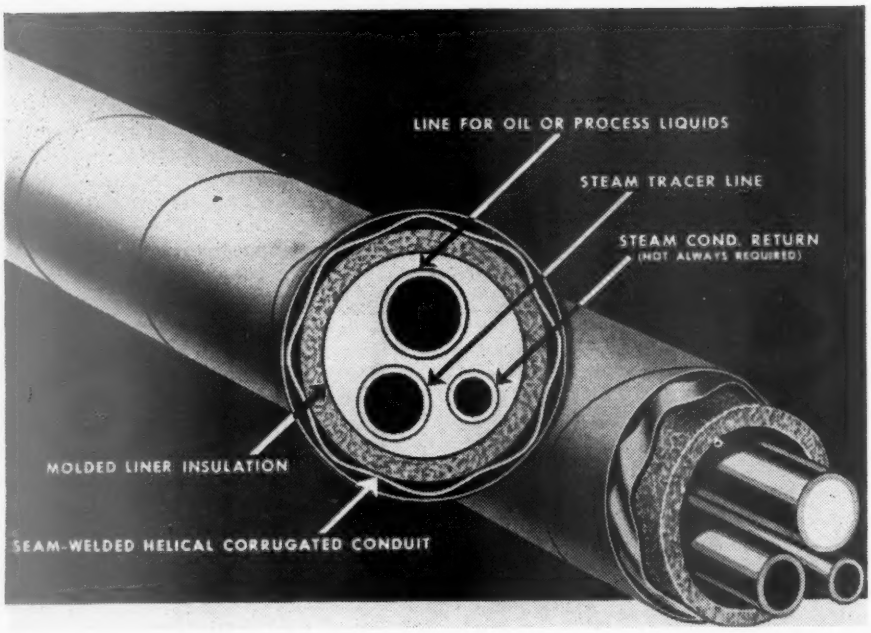
This postwar nozzle, an airfoam-making nozzle of ingenious engineering design, is fast in action, easy to work, light in weight, and efficient in service, according to the manufacturer.

The Foamite Airform-Generating Nozzle mechanically creates Airfoam through a scientific mixing of water, air and Foamite Airfoam Liquid within the nozzle, and discharges the combined ingredients as Foamite Airfoam through the nozzle tip.

It is especially ideal for extinguishing fires in flammable oils, paints, varnishes, etc.

It is a dual-purpose nozzle for it can be operated for either a foam stream, or clear water stream at the instant option of the operator by simply removing the pick-up tube from the Foamite Airfoam Liquid.





(5) Conduit systems

The Ric-wil Type UL insulated pipe unit is designed for handling oil or process liquids. By use of the system these products can be piped comparatively long distances with desired temperatures maintained. Any specified combination of pipes can be provided in prefabricated units with insulation so arranged that pipes are insulated from the exterior but not from each other. A steam or hot water tracer line heats liquids in other lines, or a brine tracer line may be used to refrigerate process liquid lines. This system is particularly adaptable to needs of refineries and synthetic rubber plants.

The conduit has an outside asphalt coating and wrapper, pre-sealed ends, and is fitted with a drive coupler for quick assembly. Insulation consists of a thick molded liner of highly efficient insulating material fitted to the inside diameter of the conduit.

Assembled units come in 21 ft lengths. Prefabricated accessories for complete installation are included. Because self-contained units will withstand repeated handling, entire systems can be relocated as often as desired.

These prefabricated pipe systems are manufactured by The Ric-wil Company, Cleveland, Ohio.

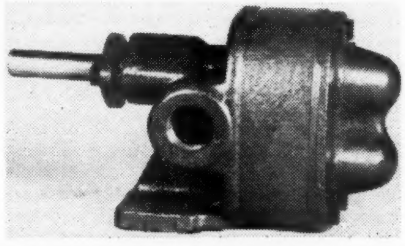
(9) GA rotary pumps

A new line of general service rotary pumps, the GA rotary type, has been introduced by Worthington Pump and Machinery Corporation, Harrison, New Jersey. Six sizes are available in various mountings for capacities up to 51 gpm and 100 psi.

These small capacity rotary pumps have been designed for durability under severest service requirements, and adaptability to variety of such requirements offered by industries, the manufacturer states. Design features include four bearing construction and special herringbone rotors. Built-in pressure lubrication eliminates all external lubrication and the danger, prevalent in many industries, of liquid contamination. A production line item, the GA rotary in its simplicity of design also offers easy maintenance and low first cost, it is asserted.

Models are available footmounted or flange mounted with adjustable stuffingbox and mechanical seal. They are also available with or without oversize unloader type relief valve. All models are suitable for direct coupling to electric motors of any make.

In the petroleum industry the GA rotary pump can be used in pilot plants, barrel house and blending service, marketing and distribution, transfer of asphalt, and in lubricating oil reclaiming plants.



(6) "Pul-Pac"

A new method of simplified material handling, with unit loads mounted on disposable carrier sheets of corrugated paper board, fiber board, or other material instead of on conventional wood or metal pallets, is announced by Clark Tructractor in introducing its newly developed "Pul-Pac."

"Pul-Pac" is a combination of a push-pull attachment for Clark forklift trucks, with a flat steel plate serving in place of conventional forks, combined with an inexpensive load base of paper or other material, to receive, lift, and carry unit loads. A hydraulically actuated gripper device moves forward, clamps an extending margin of the carrier sheet, and pulls sheet and load onto the plate. At destination the load is lifted and registered directly over the area onto which it is to be deposited, and the pusher device, working against the load, deposits the carrier sheet and its cargo in the exact desired position as the backing truck withdraws the carrier plate.

(7) Ball bearing flange

A new ball bearing flange unit known as the S C Ball Bearing Flange Bearing has been announced by Dodge Manufacturing Corporation of Mishawaka, Indiana.

This bearing is fully self-aligning, has deep groove precision ball bearing with long inner race, improved labyrinth seals, and is suitable for mounting against vertical or horizontal frames and supports. The back face of housing is machined and filling slots are also at the back, which provides added protection against external dust and dirt.

(8) Rex press-formed pumps

Chain Belt Company, Milwaukee, Wisconsin, announces the production of a new line of Rex press-formed self-priming centrifugal pumps.

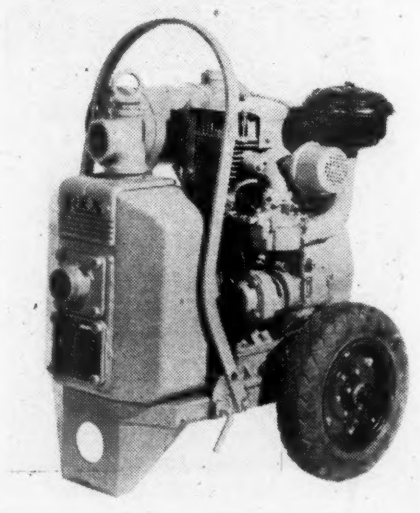
The new pumps combine attractive appearance with many features of construction that are unusual in self-priming centrifugal pump design.

The pump body is press-formed of Armco ingot iron, which is highly resistant to corrosion. Another feature of the new design is the great saving in weight. In the 2-in. size, for example, the new Rex press-formed pump weighs 90 lb less than the former cast-iron design, the manufacturer states.

The new press-formed pump body resists cracking or shattering under heavy blows—or in freezing weather, it is asserted. It can usually be repaired readily by welding.

Pumping efficiency has been improved, due, in part, to the smooth surface of the pump and press-formed volute. This results in a smoother flow of water through the pump because of reduced friction and thus betters performance.

A faster prime is assured by an improved method of priming.



(10) Lightweight slips

Texas Iron Works, Houston, Texas, has announced a new series of rotary slips that feature lighter weight and higher strength.

Known as Type A rotary slips, they are of the popular three-piece liner type. They use the same liners as the regular T.I.W. three-piece rotary slips.

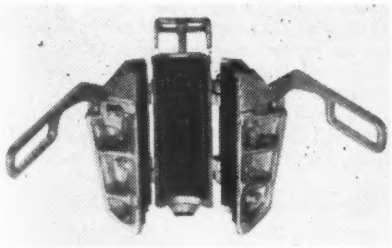
Lighter weight is achieved with no sacrifice of strength or rigidity through the use of a new body design and higher strength alloy steel, the manufacturer states.

The heat-treated alloy steel castings used for the new slips give great strength and shock resistance.

Extra rigidity is achieved by providing 30 per cent greater bearing area between slip and rotary bowl, it is asserted.

Type A slips, the manufacturer states, are easy to handle, and are long lasting.

The new slips are made in three basic body sizes and can be fitted with liners to handle pipe from 2 in. to 7 in. nominal diameter.



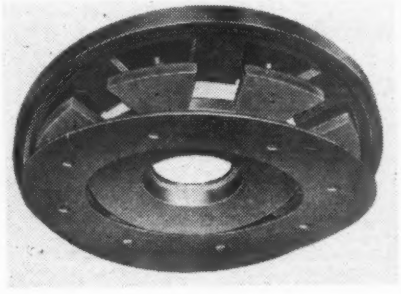
(11) Target Pipe Wiper

The Target Equipment Company, Oklahoma City, Oklahoma, announces the Target Pipe Wiper.

The top and bottom are made of hard rubber and are rigid enough that no metal reinforcing ring is necessary. The easily replaced self-locking core is made of extremely live rubber. Full size tool joints, protectors, and drill collars can be pulled through the Target Pipe Wiper without injury to any part, it is stated. The three pieces are secured into a compact unit with only eight brass tubular rivets. When replacing the core, these rivets are easily removed and installed on the rig floor without any special tools, and in a very short time.

The exclusive dovetail feature of the core provides a self-locking unit and there is really no pulling strain on the rivets. The offset portion of the core provides a double-wiping feature. The lower part gets the mud, leaving only moisture on the pipe, which is collected by the upper lip. This moisture has a tendency to lubricate and cool the rubber, which prolongs wear. The wiper is wholly resistant to chemicals and oil base mud, it is asserted.

The Target Pipe Wiper is made in all sizes—from 12 in. O. D. to 19 in. O. D. and 6⅝ in. I. D. to 2⅜ in. I. D. Distribution is exclusively by supply stores.



(12) Marion 93-M

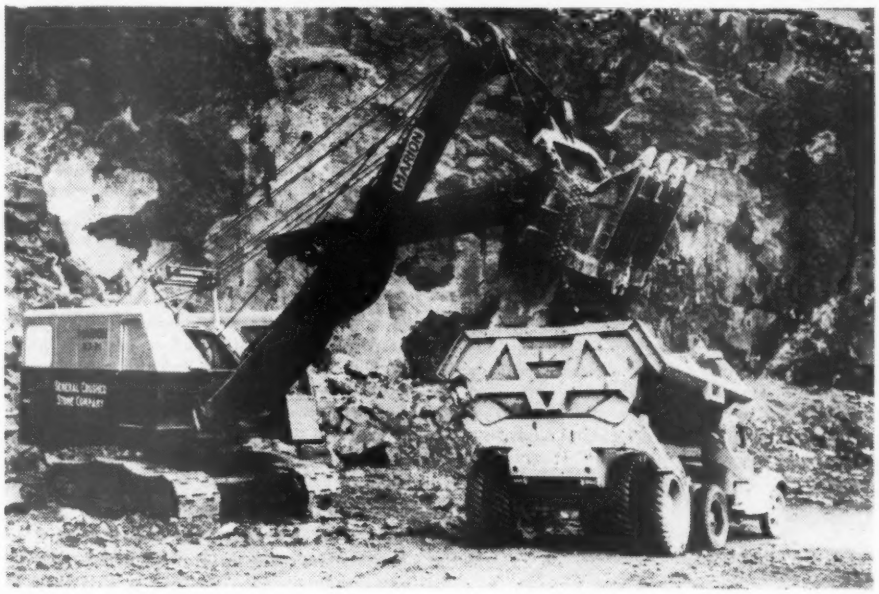
Marion Power Shovel Company, Marion, Ohio, is formally presenting the Marion 93-M, a heavy-duty, all-purpose shovel, dragline, clamshell, and crane. It is one of three new Marions since V-J Day. The Marion 93-M is a full-rated 2½ cu yd machine.

Features of the new machine include Marion air control, ease of convertibility to dragline, clamshell and crane service, ease of preparation for railroad shipment, simplicity and accessibility of all machinery and moving parts, careful proportioning of rugged construction, and ample power for heavy-duty service.

Shovel front-end equipment includes an all-welded, rounded-edge, box section boom, twin welded full box section dipper handles, and a heavy-duty manganese-steel-front dipper with inserted, socket-type dipper teeth.

For dragline or clamshell service, varying boom lengths and bucket combinations are available as job conditions may require.

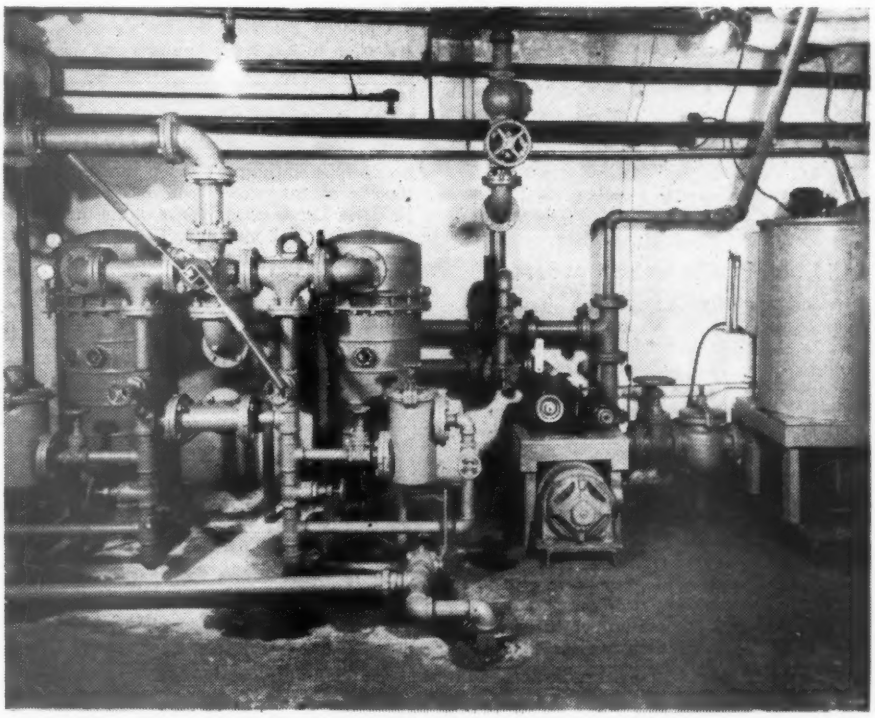
A live boom hoist is standard equipment, making the machine particularly adaptable for crane service.



(13) "Pur-O-Cel" filter

The new "Pur-O-Cel" water filter now available for small water-treatment plants makes filtering a simple, mechanical operation, not a chemical process, and requires no skilled operators, according to %Proportioneers, Inc.%, 28 Codding Street, Providence, Rhode Island. This filter, perfected in war service, utilizes thin mats of diatomaceous earth rather than a sand bed, with greatly improved filtering results, it is said.

Due to its compactness and rapid filtration rate, the "Pur-O-Cel" filter is much smaller than a sand filter of the same capacity and thereby saves floor space and reduces building costs, it is asserted. Backwashing of the filter for cleaning is easily accomplished without disassembling the unit and with a comparatively small volume of water.



(14) Liquid level transmitter

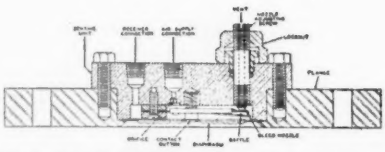
The problem of having a conveniently located instrument that will accurately indicate or record the level of liquid in a remotely located tank is now easily solved by the new, simple, highly sensitive, nonclogging, and corrosion-resistant Taylor 229RF Liquid Level Transmitter. A single compact unit measures the level of the liquid and transmits an air pressure proportional to this level to the remotely located instrument.

This transmitter is particularly applicable for measuring the level of viscous liquids or liquids with solids in suspension; the level measurement of liquids or solutions that solidify in the usual pressure or manometer connections; and relatively low pressure measurements (up to 17 psi) of corrosive gases or liquids for which the diaphragm type element is particularly suited.

The single unit consists of a metal diaphragm in a 3-in. 150-psi stainless steel flange that can be attached to the bottom or the side of an open or vented tank.

This transmitter operates on the force-balance principle. Being a 1 to 1 transmitter, the output air pressure is equal to the applied pressure or liquid head and has a range of 450 in. of water with an accuracy of plus or minus 1 in. of water.

Bulletin 98069 illustrates and gives complete and detailed information regarding this new transmitter. Taylor Instrument Companies, Rochester 1, New York, is the manufacturer.



(15) Hydraulic arbor presses

A full line of motor-driven hydraulic arbor presses—25, 50, 60, and 75-ton capacities has been announced by K. R. Wilson, Buffalo, New York. These presses are designed to provide industry with low-cost, high production units capable of relieving heavier presses of short runs or small work. Construction of the presses is extremely rugged—the frame is made of hot rolled steel. Bed plates are trussed for added strength with all joints electrically welded. The bed is easily raised or lowered by means of a cable drum and crank. As the frame is a weldment, most press dimensions may be changed to meet any particular problem at slight extra cost. Operation of the ram is controlled by a conveniently situated motor valve control that is actuated by a flip of finger and thumb. The motor-driven hydraulic pump used is a Seco radial type ranging in capacities from 3000 psi to 10,000 psi, and are practically foolproof in operation under normal care, it is stated.

All units are equipped with the exclusive KRW pressure bypass valve, permitting required tonnage pressure to be accurately set and then maintained in successive operations. Another KRW feature is the spring actuated, quick return ram that returns the ram to the "open" position instantly, when the control lever is released.

(16) Onan engine

The new Onan CK gasoline engine is a 10-hp, 4-cycle, air-cooled prime mover. Weighing only 97 lb, it has the endurance of engines several times that weight, according to the manufacturer, D. W. Onan and Sons, Inc., Minneapolis, Minnesota.

Onan engineers have long recognized that gasoline engines were classified in two categories, it is stated:

(1) Water-cooled, heavy-duty types with weight and size in direct ratio to their horsepower and stamina. The theory of engine design has been based on the premise that a water cooling system was necessary to long engine life. A water-cooled engine, however, is unavoidably bulky and heavy.

(2) Air-cooled, usually portable types. Logically an approach to weight reduction, air cooling presented many problems, and operators accepted the fact that they could not give the kind of service expected of water-cooled types. The ideal engine, therefore, would be an air-cooled type with water-cooled performance and service characteristics, Onan official state.

Important cooling features of the CK engine are listed as follows:

It is built of aluminum. Compared to cast iron, aluminum has a 4.5 to 1 ratio of thermal conductivity advantage. Aluminum construction in the CK engine assures far more rapid heat dissipation in the cylinders, the manufacturer states.

More and longer cooling fins on the cylinders and cylinder heads of the new CK allow more rapid heat dissipation.

Axial flow fan provides cool air at the rate of 600 cu ft per min at rated horsepower of the engine without absorbing an excessive amount of engine power.

Opposed cylinder design simplifies distribution of air. Each cylinder has an independent cooling area, thus eliminating heat conduction or radiation from one cylinder to another.

Several engineering improvements have been incorporated in the CK engine, aside from the factors that make it cool running, it is asserted.

(17) Filter cartridges

Hilco filter cartridges Type FHC are made up of a specially-processed cellulose offering uniform density and so packed as to eliminate the possibility of channeling. A large quantity of this type of filter element was supplied to the Armed Forces during the war, including the Navy standard size measuring 7¼ in. by 18 in. The filtering material used is suitable and has approval for filtering both the straight-run mineral oils and also the heavy-duty detergent type oils. A feature of this type cartridge includes gaskets attached to both ends, so there are no loose parts and the entire filter cartridge is metal covered to eliminate the possibility of migration of filtering material. This is of particular importance when filter elements are used in full-flow or shunt-type filtering; also filters that are equipped with a relief valve.

Users of Hilco Hyflow oil filters will be interested in knowing that these filter cartridges are available in all series of filters.

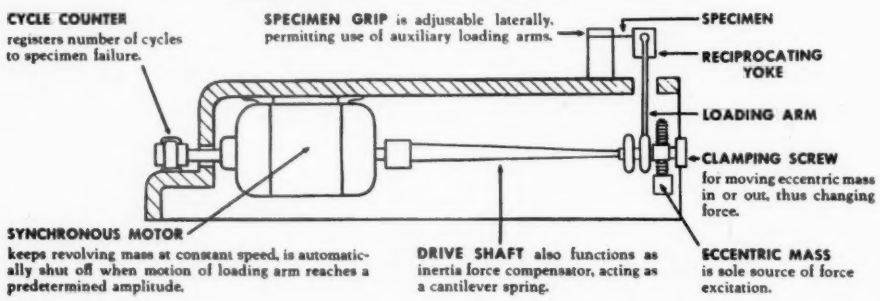
The Hilliard Corporation, 102 West Fourth Street, Elmira, New York, is the maker.

(18) Fatigue testing machine

To meet the increasing demand for a bench-type fatigure testing machine with the "constant-force" loading feature, the Baldwin Locomotive Works offers the Sonntag Model SF-2 machine. The new machine affords flexure fatigue tests on sheet stock of any material—metal, plastic, wood—and requires no attention during the test. The unusual design eliminates the need for any electronic equipment, complex linkage, or special device to maintain a constant force while the specimen is under test.

Baldwin's latest addition to its line of fatigue and simulated service testing machines uses a revolving eccentric mass as a means of loading the specimen, avoiding cams or eccentric connecting rods that require readjustment during the test as the stiffness of the specimen changes. With this constant force machine, the load automatically remains constant regardless of the changes in the amount of deflection of the specimen. A predetermined load is alternately applied to the specimen, and the resulting deflection is incidental.

Diagrammatic cross-section of Sonntag SF-2 machine.


CYCLE COUNTER registers number of cycles to specimen failure.
SPECIMEN GRIP is adjustable laterally, permitting use of auxiliary loading arms.
SPECIMEN
RECIPROCATING YOKE
LOADING ARM
CLAMPING SCREW for moving eccentric mass in or out, thus changing force.
SYNCHRONOUS MOTOR keeps revolving mass at constant speed, is automatically shut off when motion of loading arm reaches a predetermined amplitude.
DRIVE SHAFT also functions as inertia force compensator, acting as a cantilever spring.
ECCENTRIC MASS is sole source of force excitation.

McCullough hangs up *Another* Record!

4,980
HOLES SHOT IN ONE WELL
BETWEEN
7,750 AND 6,800
FEET IN JUST
78½ HOURS, TOTAL ELAPSED TIME

This world's record gun-perforating job—the greatest number of holes ever shot in one well at one time—was performed by McCullough, during December of 1946. A full string of 5½" O. D. 20 lb. N-80 casing was perforated with 4980 McCullough Burr-less Bullets in the remarkable time of 78½ hours, measured from truck arrival to truck departure. After perforating, a full-gauge rock bit, with an expansion casing scraper, was run into the well, and *no* obstruction of any kind was found, proving conclusively that *every* Burr-less Bullet completely penetrated the pipe and left *no* burrs to damage swabs, packers or other close-fitting tools. Just a large-scale demonstration of the speed and efficiency which McCullough customers have learned to take for granted through thousands of our other time-saving successful gun-perforating jobs.

McCullough *PUTS THE SHOTS WHERE THEY*

23

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McCULLOUGH TOOL COMPANY: 5820 S. Alameda St., Los Angeles 11, Cal. Export Office: 30 Rockefeller Plaza, New York 20, N. Y.

TEXAS: HOUSTON, ALICE, CORPUS CHRISTI, McALLEN, ODESSA, TYLER, VICTORIA, WICHITA FALLS
OKLAHOMA: OKLAHOMA CITY, GUYMON. MISSISSIPPI: LAUREL. NEW MEXICO: HOBBS
CALIFORNIA: LOS ANGELES, AVENAL, BAKERSFIELD, SACRAMENTO, VENTURA. WYOMING: CASPER
LOUISIANA: HOUMA, LAKE CHARLES, NEW IBERIA, SHREVEPORT. KANSAS: ULYSSES

trade literature

PUBLICATIONS LISTED ARE SENT FREE UPON REQUEST

(19) Diesel engines for the oil field

General Motors Corporation, 1504 Philtower Building, Tulsa 3, Oklahoma, has issued bulletin No. DR-113, covering the company's large diesel engine suitable for oil-field operation on drilling rigs, pipe-line pumps, and generators. This series, "the famous locomotive diesel," includes 6, 8, 12, and 16-cylinder engines that develop 540, 720, 1080, and 1440 continuous bhp, respectively, and 600, 800, 1200, and 1600 bhp, respectively, for 2-hr intermittent service.

The units are essentially self-contained and consist of the diesel engine with most of the necessary accessories attached, and a few unattached. Each engine with attached accessories is mounted on a simple rail type base that is suitable for mounting on semi-portable skids.

(20) National Supply equipment

Blueprints, sketches, "explosion" photographs, and complete specifications of The National Supply Company's Type D-5 Unit Pumper are contained in Bulletin No. 332. The pumper, which has a walking beam rating of 5200 lb, is readily adaptable for medium and high speed prime movers. The wrist pins are equipped with self-aligning roller bearings and the saddle and beam pitman bearings are the needle type that eliminate noise and rapid wear.

Complete data on the Ideal SHS-20½ Rotary Machine are given in Bulletin No. 340 issued by the same company. Photographs include shop views of the cutting of the spiral bevel gear train of the machine. The spiral gears provide smoother and quieter running because of the continuous overlapping of several teeth. Other features of the machine are the heavy duty ball type main and hold-down precision bearings and the fact that the machine is completely sealed against mud and foreign matter.

(21) I-R chemical pumps

A new bulletin on chemical pumps has been released by Ingersoll-Rand Company. This 10-page 2-color bulletin should be of interest to the general chemical industry. The bulletin is well illustrated with exploded views and cross-sectional drawings, and contains both performance and dimensional tables.

The pumps described are designed to handle many liquids and a wide range of capacities. All parts, such as castings and impeller parts that come in contact with the liquid being pumped, are constructed of Ircamet, a corrosive resistant alloy; however, other metals may be used for any particular pumping service involved.

A full page is devoted to the Cameron shaft seal with illustrations to describe its construction and action. An additional page is used for the description and illustration of the Leakollector stuffingbox gland.

(22) Manual on bearings

The Torrington Company, Bantam Bearings Division, South Bend 21, Indiana, announces the publication of a new 168-page manual, No. 15—a combined engineering and application data reference volume for ball radial, ball reciprocating, radial roller, taper roller, and thrust bearings. This manual completes a series of three volumes published by The Torrington Company to provide full bearing engineering data and, at the same time, to provide an authoritative guide in the proper selection of suitable anti-friction bearings for all types of applications.

Others previously issued in the series, include the 153-page catalog No. 32 entitled "Torrington Needle Bearings, Engineering and Application Data"; and the bulletin No. 200 entitled "Self-Aligning Spherical Roller Bearings." An attractive leatherette ring binder is provided with manual No. 15, in order that engineering vice presidents, chief engineers, chief draftsmen, and similar executives can combine the three volumes and thus have at their finger tips a handily indexed and complete reference work of anti-friction bearing information.

(23) Cummins diesel engines

Pictures and stories of nearly 100 varied installations of Cummins diesel engines are included in the first postwar edition of *The Dependable Diesel*, a magazine published by the Cummins Engine Company, Inc., Columbus, Indiana. The 36-page magazine tells of successful application of the Cummins diesel engine in the trucking, marine, logging, railroad, petroleum, construction, mining, and railroad fields, along with a number of miscellaneous applications.

(24) Small hydraulic coupling

The latest issue of *Production Road*, Twin Disc Clutch Company's magazine just off the press, is devoted exclusively to photographs, charts, and short articles that relate the complete story of the company's newest product, a small hydraulic coupling successfully tested for more than a year on electric motors and internal-combustion engines in the 1 to 25 hp range.

The magazine contains a non-technical explanation of the way the Twin Disc Clutch Company has utilized the hydraulic principle in both the familiar, large Twin Disc hydraulic coupling and the new, smaller unit.

(25) Medium duty power relay

A new 20 page catalog, No. 6, featuring medium duty power relays has been issued by Signal Engineering and Manufacturing Company, 154 West 14th Street, New York, New York.

Small power relays and medium power relays are described and illustrated, together with other pertinent information regarding method of selecting relays, operating characteristics, contact circuit arrangements, contact ratings, and other important data.

(26) Organic nitrogen compounds

"Organic Nitrogen Compounds" is the title of a new 31-page booklet published by Carbide and Carbon Chemicals Corporation, a unit of Union Carbide and Carbon Corporation. This booklet presents in detail the properties, specifications, and uses of the alkyl amines, alkylene amines, alkanolamines, and acetoacetarylamides. In chart form it gives their physical constants, comparative hydroscopicities, and neutralization curves. These compounds are used by various industries for many purposes such as emulsifying, neutralizing, synthesizing, dissolving, and saponifying.

(27) "Vee-Flex" packing rings

Raybestos-Manhattan, Inc., has issued a new 4-page bulletin describing "Vee-Flex" packing rings. The rings, automatic in their action, are designed for obtaining maximum sealing qualities with finger-tight gland compression. They are especially recommended for use in rams, hydraulic lifts, etc., against hot and cold water, steam, gasoline, mineral and vegetable oils, air, acids, milk, and beverages of all kinds, it is stated.

Selected materials are combined and accurately molded by carefully controlled methods and processes, so that they will withstand wear and provide satisfactory, dependable service on any type of hydraulic application, it is stated.

(28) Color dynamics

How scientific use of the energy in color is currently employed in the nation's plants and factories to increase overall efficiency is shown graphically in a new full-color, 32-page booklet now being published by the Pittsburgh Plate Glass Company, according to E. D. Peck, general paint manager.

With facts and figures, plus numerous views of actual use of color in manufacturing and processing plants, the booklet demonstrates how industrial officials, by following the principles of color dynamics, can (1) Promote continuity of employment, (2) improve efficiency of operation, and (3) maintain quality of production. It reveals how dynamic colors will bring about more and better work per manhour by making the employe's working environment cheerful and safe.

(29) Diaphragm control valves

H. Belfield Company, Philadelphia, Pennsylvania, his issued Bulletin No. 500 describing the new Belfield diaphragm control valves, Series No. 700. This series consists of a complete line of diaphragm motor control valves for a great variety of applications. The diaphragm motor features a number of new refinements that incorporates the results of years of field experience in this new development.

(30) Tachometer catalog

A new 16-page catalog featuring the extensive line of tachometers manufactured by Jones Motrola Corporation, 436 Fairfield Avenue, Stamford, Connecticut, is available. This catalog describes and illustrates different tachometers for particular applications, lists ranges and driving ratios, and other pertinent information regarding continuous indicating portable and fixed mounted types, and the accessories required for many standard and special driving arrangements.

(31) Oil Base, Inc., handbook

Oil Base, Inc., Los Angeles, has issued a 64-page pocket size handbook pertaining to Black Magic oil drilling fluid and conventional clay-water mud covering valuable information in condensed form of formulas for mixing additives, testing procedure, formulas for mud weight and volume increase, conversion factors, pump capacities, drill pipe sizes, capacities of casings, pits and tanks, and many tables and charts useful to the man in the field. Much of this information has been compiled for the first time into one complete volume small enough to carry in a shirt pocket. Protected by a waterproof cover, the manual provides blank pages in the back for additional notes.

VETERAN OF *The Oil Fields*

When severe pressures threaten your strings . . . when extra pullout strength is demanded . . . that's the time you need the time-proved veteran of the oil fields—Republic Electric Weld Casing.

The proved performance of more than 130,000,000 feet of Republic Electric Weld Casing and Tubing covering almost two decades of time indicates that you can rely upon these products for dependable service under all conditions.

High strength and toughness combine with uniform roundness to resist collapse. Accurate threads with plenty of metal under all thread roots—insured by uniform wall thickness —provide high joint strength.

For long service . . . for dependability . . . for fast make-up . . . insist upon Republic Electric Weld Casing.

REPUBLIC STEEL CORPORATION

GENERAL OFFICES • CLEVELAND 1, OHIO

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INSPECTED INSIDE AND OUT

Republic Electric Weld Casing and Tubing are made from flat-rolled steel, both sides of which can be inspected. Thus, the surface which becomes the inside wall is free from hidden defects.

REPUBLIC

LINE PIPE

NORMALIZED CASING AND TUBING

Other Republic Products include Alloy Steels—

Utilization of residue or oil well gas*

by **W. K. DAVIS,** *Production Superintendent,* El Paso Natural Gas Company

I HAVE been asked by a group of engineers in Midland, Texas, to prepare a paper for this meeting, outlining the general plans of the El Paso Natural Gas Company to gather gas for delivery to California. This project has been previously discussed by Mr. Paul Kayser, president of the El Paso Natural Gas Company, and it will be necessary for me to repeat portions of his article in my discussion with you.

In August, 1945, the El Paso Natural Gas Company filed application with the Federal Power Commission for the necessary certificate to permit the company to construct and operate a 26-in. pipe line to California.

On May 31, 1946, the Commission granted our application exactly as requested. On July 2, 1946, we concluded the necessary financing and on July 23, 1946, placed $42,212,000 cash in the bank as a construction fund for the completion of the project.

This line performs two important public services. It provides a market for a minimum of 125,000,000 cu. ft. of residue gas per day that otherwise would be blown to the air, and it supplements the decreasing gas supply of Southern California, one of the most populous and fastest growing areas in the United States.

This project, when completed, will consist of approximately 737 miles of 26-in. pipe extending from a point near Jal, New Mexico, through southern New Mexico and southern Arizona to a point on the California-Arizona line near Blythe, California, as shown on the map. The solid black line represents the existing pipe line system. The dotted line represents the new pipe line to California. The dark circles represent the proposed compressor stations. The cross-hatched line represents that portion of the line to be constructed and operated by the California companies. The pipe line is designed to operate at 810-lb. pressure with a maximum operating pressure of 838 lb. The pipe will be one-half 0.291 wall thickness and one-half 0.281 wall thickness, with the 0.291 wall pipe on the discharge side of the compressor stations and the 0.281 pipe on the suction side. The line from Dumas, Texas, to Eunice, New Mexico, will be 24 in. in diameter and 251 miles in length. The field gathering system will consist of 31 miles of 14-in. pipe from the Eunice plant to the Fullerton field, and 31 miles of 16-in. pipe from the Jal No. 1 plant to the Keystone and TXL fields; 46.5 miles of 14-in. pipe will be laid from the Jal No. 1 Plant to the Pecos River where it will join the 26-in. line from the Eunice plant.

The ditch will be 42 in. wide and 56 in. deep giving a 24-in. cover over the

*Presented at joint meeting, Texas sections, American Institute of Mining and Metallurgical Engineers, at the University of Texas, Austin, December 18 and 19, 1946. Original title: "The Utilization of Residue or Oil Well Gas by the El Paso Natural Gas Company in Connection With Its Texas-California Gas Pipe Line."

RECTORHEAD

TUBING & CASING HEADS...

...are the world's

"Easiest to Install"

and the

"Safest of All!"

Only RECTORHEADS give you these twin advantages of christmas tree efficiency, because they alone utilize the industry accepted, field-proven metal-to-metal seal in its most simplified form.

There is no resilient packing in either casing or tubing heads . . . no complex arrangement of sealing elements to be installed in the head with hanger . . . no welding flange subject to flange bolt distortion during and after welding . . . no stress relieving is required because the floating welding ring is at all times free of tension. The weld in the casing head is made on any grade of pipe, in less than one hour, by your regular field welder without the use of special equipment or skill.

Permanent leak-proof safety of these seals is assured because they will not deteriorate . . . will not burn out in event of fire . . . will not contract in freezing temperatures . . . require no replacement.

Save time and cost in christmas tree installations and at the same time get permanent, dependable protection for your well by using RECTORHEAD tubing and casing heads.

RECTOR WELL EQUIPMENT CO., Inc.

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pipe. In general, the ditch will be dug with a ditching machine except in the mountain passes such as the Guadalupe Mountains, Stien's Pass, and Apache Pass, where dynamite and backhoe machines will be necessary. We will build suspension bridges over the Canadian River, Pecos River, San Pedro River, Gila River, and Colorado River, and a structural steel bridge over the Rio Grande River. In general, the soil conditions are not too bad; however, we will install cathodic stations at the necessary intervals to protect the pipe from electrolysis and all of the pipe will be primed, coated, and wrapped to protect it from corrosion (primed with regular primer and coated with coal tar pipe line enamel and wrapped with 15-lb. felt paper).

In the first year's operation under the 125,000,000 cu. ft. per day delivery, it will be necessary to install one main line compressor station and the necessary compression in connection with the field gathering system.

In the second year of operation, which calls for the delivery of 175,000,000 cu. ft. per day, the company will lay a line to Dumas, Texas, for the purpose of picking up 50,000,000 cu. ft. of gas per day from the Panhandle field in North Texas. It also will be necessary to construct and operate one additional compressor station on the main line to meet the above deliveries.

The outstanding feature of this project is that it provides a market for a vast amount of oil well gas that has been going to waste in West Texas and Southeastern New Mexico for a number of years. It is unique in that it is the first large gas transmission line to market more than 75 per cent of its total requirements from residue or oil well gas.

During the first year's operation the gas to be marketed will be 100 per cent residue gas or oil well gas. This gas will be taken from the Eunice and the Monument fields in New Mexico and the Fullerton, Keystone, and TXL fields in West Texas.

It is expected that it will require approximately one year to construct the initial stage and approximately 18 months to complete the pipe line to a capacity of 175,000,000 cu. ft. per day.

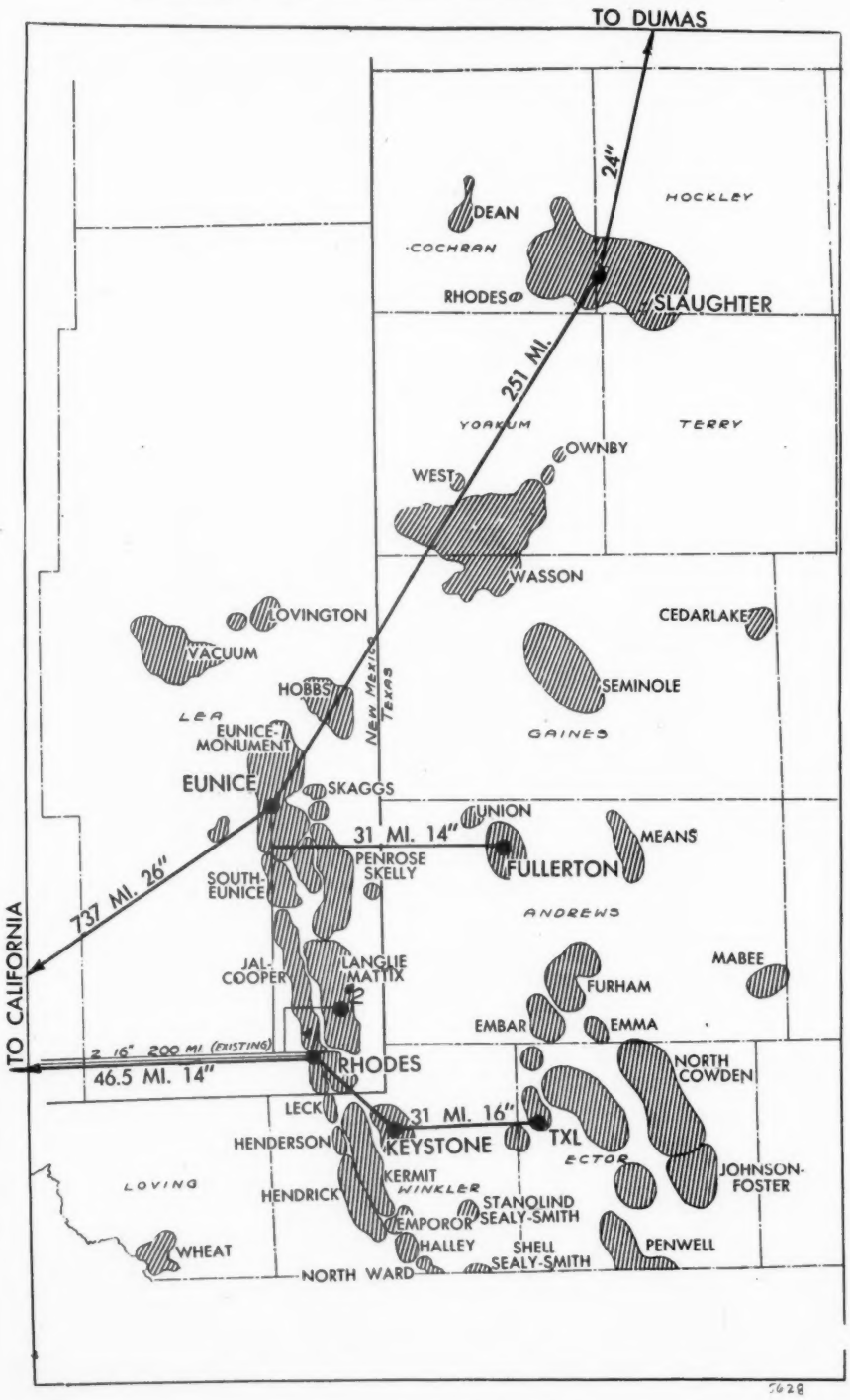
When the maximum capacity of the line is reached, which is 305,000,000 cu. ft. per day, it will be necessary to have installed, six main line compressor stations and seven field compressor stations having a total of 131,800 hp. in operation. In addition the company will be operating several desulphurization and dehydration plants necessary to prepare the gas for distribution. The project also includes many automatic devices, which will make it one of the most complete pipe lines in the world.

The initial proposal involved the marketing of 125,000,000 cu. ft. per day of residue gas produced in connection with oil in the Permian Basin fields in Southeastern New Mexico and West Texas, which gas is otherwise being blown to the air. However, in order to permit entering into a long-term contract with the California companies and to satisfy the requirements for financing the new project, it was necessary to broaden the base of supply by attaching reserves of so-called "dry gas" not associated with the production of oil.

To this end, the El Paso company contracted with Phillips Petroleum Company for deliveries of 75,000,000 cu. ft. of residue gas per day from four gasoline absorption plants in oil fields near the eastern terminus of the new 26-in. line and for an initial supply of 50,000,000 cu. ft. per day of "dry gas" to be produced from the western portion of the Panhandle field in Moore County and adjacent counties in North Texas and from the southern portion of the Hugoton field in Sherman County, Texas, with the right to the El Paso company under certain circumstances to increase its takings of dry gas from the two last mentioned fields up to a maximum of 180,000,000 cu. ft. a day.

The El Paso company also contracted with the Gulf Oil Corporation for 30,000,000 cu. ft. per day residue gas from a gasoline extraction plant to be built by Gulf in the Keystone field in Winkler County, Texas; with the Shell Oil Company for 20,000,000 cu. ft. daily residue gas from a gasoline extraction plant to be built by Shell in the TXL and Wheeler fields in Ector County,

Index map of West Texas and southeastern New Mexico.



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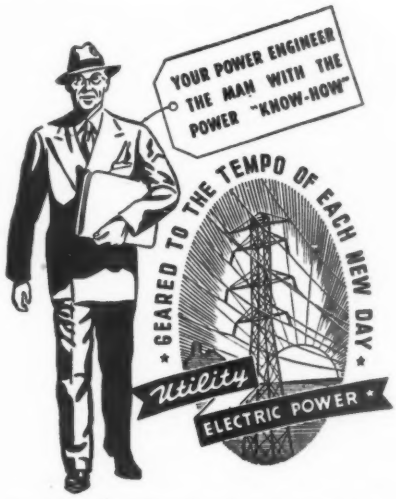

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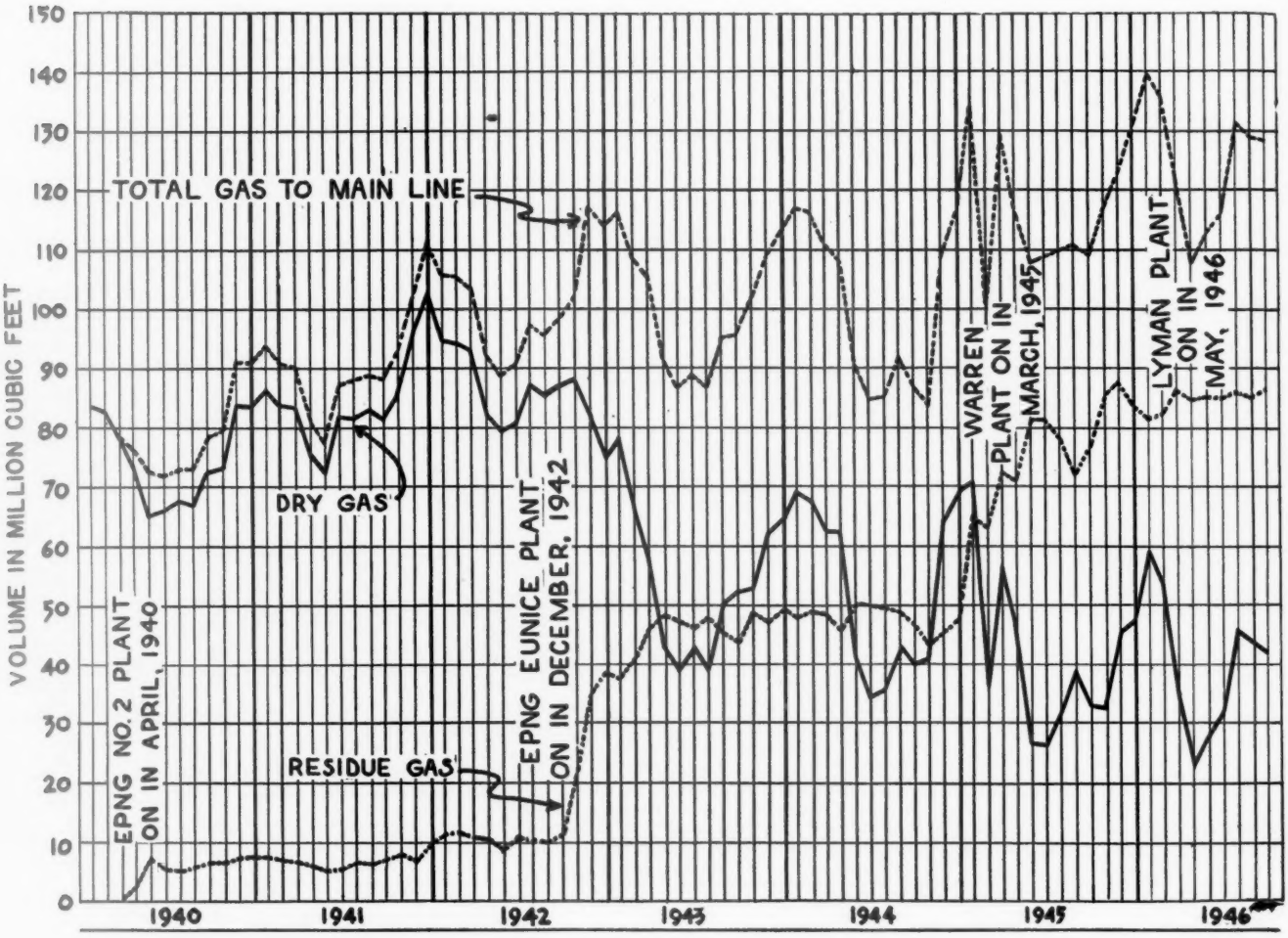

Average daily gas deliveries, El Paso Natural Gas Company, 16.4-lb pressure base.

Texas; and with Warren Petroleum Corporation for 10,000,000 cu. ft. residue gas from the Monument field in Lea County, New Mexico. These contracts are for terms from 15 to 25 years. The average purchase price of a reasonable quantity of gas at any central location is 3½ cents per M. cu. ft. for the first five-year period with the price gradually increasing each succeeding five-year period thereafter for the term of the contract.

On December 17, 1945, the El Paso company entered into a contract with Southern California Gas Company and Southern Counties Gas Company of California, under which the El Paso company undertakes to deliver to them at the Colorado River near Blythe, California, up to 125,000,000 cu. ft. of natural gas per day during the first year of the contract term and up to 175,000,000 cu. ft. of gas per day thereafter, with an option to the California companies, exercisable on or before September 1, 1949, to increase their takings under the contract to a maximum of 305,000,000 cu. ft. of natural gas per day. The California companies are to construct a line from the point of delivery at the Colorado River to a connection with their present distribution system near Los Angeles. The contract, which is to continue for a term of 30 years from the initial delivery of gas thereunder, obligates the California companies to receive minimum deliveries, averaged over the year, of 91 per cent of the maximum contracted daily demand from time to time in effect as indicated above.

Upon application of the California companies and after hearings, the California Commission on February 5, 1946, issued its opinion and order approving the construction of the line from Blythe to Los Angeles, and emphasizing the need of the two California companies to obtain additional gas to supplement the diminishing supplies available to them from California sources and to enable them to meet the full anticipated demands from their service areas.

The California companies also made application to the Federal Power Commission for authority to construct and operate their portion of the new project as an interstate line. Such application was, by order of the commission, consolidated with the El Paso company's application for purposes of hearings, and an initial hearing on the two applications, for the presentation of direct evidence, was had in Washington, D. C., in February of this year. Further hearings for additional direct evidence and cross-examination were had in Los Angeles from April 8 to 15, 1946. No organized opposition to the applications appeared at any of the hearings; on the contrary, the city of Los Angeles, the city of San Francisco, and the Chamber of Commerce of Los Angeles, through their respective representatives, appeared at the hearing in Los Angeles and urged the granting of the applications.

In preparation for the hearings we presented more than 200 exhibits showing the estimated available reserves for all the major fields in the Permian Basin, the engineering design and the proposed financing of the entire project for a 30-year period.

During the Federal Power Commission hearing in Los Angeles, executives of the California companies stated on the record their conviction that their companies would need the full 305,000,000 cu. ft. of gas per day, in all probability at an earlier date than was originally contemplated, and made a formal offer to exercise at this time their election to take the full 305,000,000 cu. ft. per day, pursuant to the terms of the contract, if the Federal Power Commission should deem such action on their part necessary to permit the issuance of unconditional Certificates of Public Convenience and Necessity covering the entire new project, as asked by the El Paso company and the California companies. The commission, however, did not require the exercise of the option prior to September 1, 1949, but granted

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the certificate for the full 305,000,000 capacity conditioned only upon the exercise of the option by September 1, 1949.

The marketing of sizable quantities of residue gas is not a new experience to the El Paso company. In the operation of the existing pipe lines in New Mexico and Arizona they have been utilizing various quantities of residue gas in the company's system since 1940 and in 1945 approximately 65 per cent of the systems total requirements were from residue gas. In the year 1940 they constructed a gasoline absorption plant in the Langlie-Mattix area in Lea County, New Mexico, and at the same time installed the necessary compression to boost approximately 8,000,000 cu. ft. per day into the main lines for delivery through the transmission system.

In 1942 additional compressors were installed in the plant in the Langlie-Mattix area and a residue compression plant was constructed in the Eunice field to utilize residue gas that was blowing to the air from the Phillips Petroleum Company's Oil Center gasoline plant.

In 1945 additional compressors were added to the Eunice plant that allowed increased residue gas takes from the Phillips' gasoline plant in the Eunice field and from the Warren gasoline plant in the Monument field in Lea County, New Mexico.

In 1941 the average amount of gas sold through the El Paso company's main line was approximately 90,000,000 cu. ft. per day. Of this amount, approximately 8,000,000 cu. ft. per day or 9 per cent was residue gas.

In 1943 the average daily amount of gas sold through the El Paso company's main line was approximately 105,000,000 cu. ft. Of this amount approximately 45,000,000 cu. ft. per day, or 43 per cent, was residue gas.

In 1945 the average daily amount of gas sold through the El Paso company's main line was approximately 115,000,000 cu. ft. Of this amount approximately 75,000,000 cu. ft. per day, or 65 per cent, was residue gas from fields in Southeastern New Mexico.

On the basis of this operation the El Paso company was convinced that it could construct and operate a large gas transmission line that utilized residue gas in conjunction with a dry gas reserve attached to the system, provided that it could contract for residue gas produced from oil reservoirs with a sufficient reserve to warrant several years of operation of a compressor, desulphurization and dehydration plants.

There are many important factors to be considered in the utilization of residue gas in a gas transmission system. Obviously, it would be impossible for a gas company to install and operate equipment utilizing 100 per cent of the total gas produced from any oil field. The most important factors to be considered are the daily variations of available gas within the 24-hr. period, the variations of available gas over a monthly period, amount of gas that will be required to be returned to the leases, and the amount of gas required for fuel, absorption, and other purposes for the operation of a gasoline absorption plant and a compressor plant; the variation of field allowables over a period of time and the estimated future decline of the oil and gas production in the field. All these factors must be taken into consideration in order for the gas company to be assured of a continuous supply of gas available for the necessary equipment required to compress the gas from low pressures to high pressures. If the above factors were not considered it would be possible to have a situation where large sums of money would be tied up on equipment that would be idle a large part of the time and thereby create an excess cost per M. cu. ft. of the gas.

Another important factor to be considered in this connection is the possibility of any repressuring within the field. This, of course, if looked upon favorably by a gas company due to its conservation of natural gas. However, it is desirable that the repressuring agreements be consummated prior to the installation of residue equipment, so that definite and continuous quantities of gas can be made available over a long enough period of time to warrant the installation of the necessary equipment.

In 1942 the El Paso company purchased the leases and gas reserves down to 4000 ft. from several of the operators in the Rhodes area in Lea County, New Mexico, and proceeded to work out a unitization agreement with the federal government for the purpose of operating a gas storage project.

The Rhodes Unit is favorably situated in respect to the operation of the existing system and the proposed project. It is about four miles southeast of the El Paso company's Jal No. 1 plant, which is just south of the town of Jal, New Mexico. The area has produced gas into our system since the first deliveries of gas by the El Paso Natural Gas Company and consequently a vast amount of information with respect to geological conditions, production history, and pressure records, are available. It is believed that the storage reservoir will be advantageous in the operation of the existing and proposed pipe line in connection with the utilization of large quantities of residue gas. It is anticipated that this reservoir will be operated as an "in and out" proposition. In the summer time when the deliveries of gas are at a minimum, the excess residue gas will be stored into the storage reservoir rather than shutting down the compressor stations and in the winter months during peak demand periods the gas will be produced into the main line. This is advantageous in two ways: First, it will conserve residue gas by storing it in the summer and producing it on peak demand in the winter; second, it will have a stabilizing effect on the dry gas wells tied to the existing system in that they will not be required to be produced at high rates of production, thereby minimizing the possibility of reservoir damage due to excess production. Also, it will conserve dry gas for future use. This storage reservoir will be valuable as a stand-by in case of plant or line failure at any point prior to entry of gas into the 26-in. main line. To date 1,100,000 M. cu. ft. has been stored in the reservoir, increasing the average bottom hole pressure of the unit approximately 110 lb.

There can be little question that the California project will have a very favorable effect on the future conservation of residue or oil well gas and, no doubt, other gas transmission companies will include in their future plans the utilization of all suitable residue gas.

Upon completion of the second stage of operation of the California project the El Paso Natural Gas Company will be marketing over 210,000,000 cu. ft. of residue or oil well gas per day through its system and in my opinion the creation of a market that gives residue gas a definite value is the best way to effect natural gas conservation.

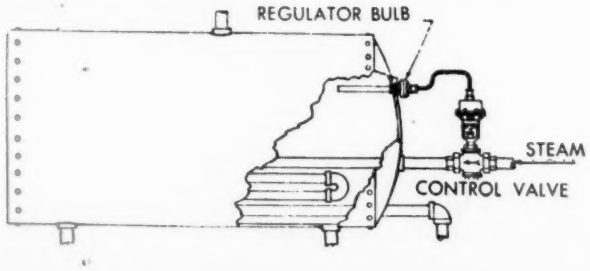
Acknowledgments:

Acknowledgment is made to the El Paso Natural Gas Company for permission to prepare the paper and to the engineering department for its assistance in preparation of certain portions of this material. ★ ★ ★

P 094.81

Simple steam line control

By W. F. SCHAPHORST



A SIMPLE way in which to control steam lines up to 2½-in. diam. for maintaining high temperature in a tank of water is shown in the accompanying sketch. Place the regulator bulb in the tank, as indicated, and the control valve directly in the steam line. The vapor pressure in the regulator bulb causes the control valve to open and close with variation in temperature. In this way any temperature from 70 to 300 F can be maintained in either open or closed tanks or heaters. ★ ★ ★

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Cathodic protection*

By C. H. McRAVEN, *Corrosion Engineer*
The Texas Pipe Line Company

BASICALLY a cathodic protection unit consists of a source of direct current, the negative terminal of which is connected to the pipe line to be protected and the positive terminal to the ground some distance from the pipe line. The ground connection is usually made by means of buried junk pipe or other expendable material, usually referred to as the ground bed. In operation, current flows in the conventional sense from the positive generator terminal to the ground bed, thence through the ground to the pipe line and from there to the negative terminal of the generator. By this means corrosion of the pipe line is reduced, while corrosion of the ground bed is increased; corrosion is transferred from the structure to be protected to a structure that can be replaced at relatively small cost.

All cathodic protection systems follow this general plan although in details they may differ widely. One line may have a coating that will make it possible to protect several miles of pipe with one unit; another line may require several units to protect the same length of line and in some cases a line may require a system consisting of a ground bed distributed along the line and fed at frequent intervals. The corrosion engineer must study each protection job individually and decide which arrangement of the basic elements is the best suited for that particular project.

In the following an attempt has been made to explain the theory of how cathodic protection stops corrosion and to review some of the basic laws governing the flow of current in the networks encountered in its application.

One of the principal charactertistics of corrosion on a pipe line is that it almost always occurs in small spots or patches while there is little evidence of attack on the surrounding surfaces. It can be shown by electrical measurements that an electric current flows from the pipe to the soil through the corroding spots and from the soil back to the pipe through the non-corroding areas. The areas that discharge current or that corrode are known as anodes and those that collect current are known as cathodes. One of the most common forms of corrosion encountered in pipe line maintenance is that caused by differential aeration. In this form part of the surface area has a relatively plentiful supply of oxygen that reacts with the iron at the surface to form an iron oxide film in intimate contact with the underlying steel. This film serves as a protective coating for those areas preventing moisture in the ground from coming in contact with the steel. If this oxide film could be formed and maintained evenly and completely over the entire surface of the pipe, it would serve about the same purpose as a nickel plating. In practice, however, there are always certain spots or areas that are more or less shielded from oxygen. A 100t pressing against the pipe will retard the diffusion of oxygen to the underlying steel. Areas having a deficiency of oxygen will become anodes and will corrode and those with a more plentiful supply will become cathodes.

The cathodes present an oxide surface to the soil, hence they are, in effect, oxide electrodes. The anodes, where there is not enough oxygen to maintain an oxide film are, in effect, steel electrodes. The two are unavoidably bonded together by the metal in the pipe, which completes the closed circuit through which current flows, i.e., from pipe to soil through the anodes, back to the pipe through the cathodes, and from the cathodic areas to the anodic areas along the pipe.

At the anodic areas current flowing from pipe to soil carries iron particles with it that move out from the anode surface until they contact oxygen with which they combine to form iron oxide. This action gives rise to the familiar "shell" of corrosion products so often found covering a pit. The shell is formed too far from the corroding surface to stifle corrosion; instead it further retards the diffusion of oxygen up to the anode, thereby aggravating the situation. Therefore this type of corrosion when once started, if left alone, will continue until the pipe is penetrated.

It has been found that if current is prevented from flowing from pipe to soil at all points, corrosion will stop. This is what cathodic protection does. We have a section of pipe line with innumerable small local action short circuited cells acting to circulate current between adjacent areas on the surface. If we now superimpose another current from an external source so that it flows from soil to pipe at all points, it will buck the galvanic current leaving the anodes and increase that already flowing toward the cathodes. There is some value of externally applied current that will buck the anode current to zero and stop corrosion at those points.

Once this condition has been achieved and the iron particles stop leaving the anodic areas, there is nothing to prevent oxygen from eventually diffusing up to the surfaces that were originally anodic and there forming an oxide film as exists on the cathodic areas. Thus, the effect of cathodic protection is not only to stop corrosion but also to reduce the tendency for corrosion to take place. For this reason it is often possible, after a cathodic protection system has been in service for some time, to reduce the current from the external source. That is less current is required to prevent corrosion from starting than is required to stop it once it has been allowed to reach its normal rate.

If the applied current is increased materially above that required to barely stop corrosion, the normal potential between the pipe and soil changes; the soil becomes more positive with respect to the pipe. In other words, a voltage is developed across the junction between the pipe and soil in such a direction as to oppose the applied current. This is called polarization and is much the same phenomenon that occurs when a storage battery is charged.

The problem of how to determine when the externally applied current is sufficient to stop corrosion is one of the most difficult questions in the whole subject. The designer of a cathodic protection system should know ahead of time what current is required at certain points along the line to enable him to select the proper equipment. One of the most commonly used methods is by means of so-called pipe-to-soil potential measurements.

Before discussing how these measurements are used, it is best to explain what they are. To begin with, the soil contains a solution of water and whatever soluble substances happen to be present, the nature of which determines the corrositivity of the soil. From a corrosion standpoint, the soil may be considered to be a solution or electrolyte. When we make a "pipe-to-soil" potential measurement, it is necessary to contact the soil with some kind of electrode and to connect the voltmeter between that reference electrode and the pipe. The voltage measurement so obtained is the voltage of a galvanic cell composed of the pipe as one electrode and the reference electrode as the other, both immersed in the moist earth. It is similar to the voltage between the two terminals of the conventional dry cell battery in which one electrode is zinc and the other is carbon. The total voltage observed across the terminals is the algebraic sum of the voltage between the zinc and solution and the voltage between the carbon and solution. We cannot measure each individually; we can only measure the sum of the two. The same thing applies to a voltage measurement between a pipe and reference electrode and obviously the voltage observed is affected not only by the conditions at the surface of the pipe but also by the nature of the reference electrode used. If we use a copper rod as reference one value of voltage is obtained; if we use a rusty steel rod another value is obtained; if we brighten the same steel rod, the voltage will again change. In order for the measurements

*Presented at the Texas College of Arts and Industries' Short Course in Gas Technology, August 28, 1946.

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to tell us anything about conditions at the pipe surface, it is necessary to use a reference electrode that always contributes substantially the same amount of voltage to the total voltage measured, regardless of where it is placed in the earth. Several such electrodes have been devised, all embodying the same principle. The copper-copper sulphate electrode is the one most commonly used in the field; a copper electrode is surrounded by a saturated solution of copper sulphate in a porous container. In use the earth is contacted by the sulphate solution through the porous container; the solution also contacts the copper electrode to which the voltmeter is connected. With this arrangement, the copper is always in contact with the same solution and the voltage existing across the metal solution junction remains constant enough for practical purposes. We do not know what that voltage is, nor is it necessary that we should know; all we need to know is that it is constant. Throughout the remainder of this paper wherever the term "pipe-to-soil potential" is used, it will be understood that the voltage referred to includes the constant voltage contributed by the copper sulphate electrode, unless otherwise noted.

To get back to the use of pipe-to-soil potential measurements to determine when a pipe is completely protected, let us imagine ourselves in the ground close to the pipe and free to move about and make measurements without disturbing the earth. If we find a corroding spot and place the reference electrode so that it contacts the soil close to that spot, the electrode would be found to be possibly 0.8 volt positive to the pipe. It is convenient to imagine that there is a pump at the surface of the anodic spot pumping current out of the pipe into the surrounding earth. The voltmeter terminal connected to the pipe is connected to the suction side of the pump and the other terminal, connected to the electrode, is connected to the discharge side. Now if we move the electrode along the pipe away from the corroding spot until it lies close to an area where no corrosion is occurring, it will be found to be less positive to the pipe, possible 0.3 volt. As before, a pump may be imagined at the cathode surface but in this case it is pumping current from the earth to the pipe. The electrode is now located on the suction side of the pump, hence its potential will be lower or more negative than it was when it was placed near the corroding spot. In this illustration, two pumps were assumed to be acting in series with each other, both in the direction of the current flow. Actually they may be opposed to each other, with one having a higher discharge pressure than the other; or there may be only one. In any case, the same conclusion is reached: That is, the earth potential relative to the pipe is more positive adjacent to a corroding spot than it is near a non-corroding spot.

Now if the electrode is moved away from the pipe, its potential will be influenced by both the anodic and cathodic areas and so will assume a potential somewhere between the 0.8 and 0.3 volt used as illustrative values above; a potential that is an average of the effect of all the anodes and cathodes on the pipe in that immediate vicinity. This is the way pipe-to-soil potential measurements are customarily made; with the electrode some distance from the pipe, usually on the surface of the ground over the pipe.

If a direct current generator is now connected with its negative terminal to the pipe and its positive terminal to the ground, the potential of the latter is forced to move more positive with respect to the pipe. When the potential of the soil around the pipe is raised to a value equal to or greater than the discharge pressure of the anodic "pumps," the discharge of current from those areas stops and consequently corrosion also stops.

The pipe-to-soil potential now includes a portion of the generator voltage equal to the resistance between a cylindrical equi-potential surface around the pipe contacted by the reference electrode and the pipe multiplied by the generator current.

It has been found in practice that when the soil potential has been forced to a value slightly greater than 0.8 volt positive to the pipe, the frequency of leaks drops off sharply and in most cases drops to zero. Hence the rule of thumb that states that when the pipe-to-soil potential is made greater 0.8 volt, complete protection has been achieved.

It is possible that in many cases raising this voltage to 0.8 results in over protection and a consequent extra expense for power and equipment.

Another method frequently employed is to apply enough current to change the pipe-to-soil potential by 0.3 volt. That is, if the normal pipe-to-soil potential was 0.4 volt and the application of cathodic current raised it to 0.7 volt, it is assumed that satisfactory corrosion control has been achieved.

Probably the most exact method is that in which the galvanic voltage between pipe and reference electrode is plotted against the applied current as the latter is increased by steps from zero to several times that required for full protection. From the shape of the curve thus constructed, the value of current at which corrosion was stopped can be determined.

There are arguments both for and against all these methods. Probably each is the correct method in certain localities and has developed as a result of experience in those localities. In cases where protection is applied to a line on which leaks have occurred, the stoppage of leaks after protection is a sure indication that the protection is adequate regardless of which inferential method is used. However, dependence on the leak records alone is not satisfactory from the management's viewpoint, for it would be necessary to make the expenditure for protection before it was known what the benefits would be. At present the design of cathodic protection systems is mainly dependent on good judgment based on experience in the particular section of the country where protection is desired.

The current required to provide protection to a section of pipe line varies over rather wide limits. In most cases the controlling factor is the coating on the line. Obviously, if a line is well coated, very little applied current will leak through the coating; almost all the current will enter the pipe through breaks in the coating. Consequently, a little current will protect a relatively long section of such a line. On the other hand, if the line is bare, the type of soil that the line traverses becomes the controlling factor. The soil varies radically from point to point along a pipe line, consequently the current requirements also vary. As an illustration, certain tests in three different waters showed that to stop normal corrosion of sanded mild steel coupons in sea water required an average of 6 milliamperes per sq. ft.; in brackish water, 4 milliamperes, and in fresh water, 12 milliamperes.

The condition of the pipe surface when the pipe is laid should also have some effect on the current required insofar as it affects the final condition of the surface after normal steady corrosion has been established. If a line is laid without first removing the mill scale, places where the scale has been damaged and the underlying steel is exposed will be anodic and will corrode, tending to prevent corrosion of the areas where the mill scale is intact. In this case, the distribution of anodic and cathodic areas is predetermined to a large extent when the line is first laid. On the other hand, if the pipe is first run through a cleaning machine and the mill scale removed, its surface is made more or less uniform, and the final arrangement of anodic and cathodic areas will be determined almost entirely by soil conditions met with

Canol project for sale

The bulk of the Canol oil refinery-pipe line project in northwestern Canada has been placed on sale by the U. S. government because it has no known economical postwar use. Most of the $134,000,000 project will be offered for sale as surplus property under an agreement signed with Canada.

The project was planned by the U. S. Army as a means of getting military fuel supplies to Alaska when the Japanese threatened that territory during the war. It was abandoned three years ago under a charge of waste.

Only facilities not for sale are the pipe lines from Skagway to Whitehorse and from Whitehorse to Watson Lake and to Fairbanks, Alaska. These have not been declared surplus and for the present will remain property of the U.S.A.

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after the line is laid. The final surface conditions in these two cases will be different; the distribution and extent of the anodic areas will be different, and probably the voltage of the local action cells will be different, resulting in different values of current required for complete protection.

Considering the various factors that control current requirements it appears that the most practical method of predetermining those requirements is by actual field tests with temporary ground beds and portable generating equipment. Usually a satisfactory temporary ground bed can be made by installing a number of ¾-in. or 1-in. pipes about 6 ft. long in hand drilled holes with the spacing between holes about 20 ft. Backfilling with soil mixed with salt water helps reduce the resistance between the rods and earth. The number of rods required will depend on the soil resistance and on the available voltage of the generating equipment. The rods are connected in parallel to the positive terminal of the generator; the negative terminal is, of course, connected to the pipe line.

In making these tests it is customary to measure the normal pipe-to-soil potential at various points throughout the section where protection is desired before the test current is applied. Then the test current is adjusted to some arbitrary value and the pipe-to-soil potentials at the same points as before are re-measured. From the data thus obtained and past experience the engineer can make a reasonably accurate estimate of the protection obtainable from a cathodic unit at that location with a current output equal to that used in the test.

In general, cathodic units should be placed along a pipe line at points where leaks have occurred, or if there have been no leaks, at points where trouble is anticipated, judging from soil surveys or from experience with other pipe lines in that vicinity. More often than not, however, other factors enter into the selection of the location of a cathodic unit: Availability of a dependable source of electric power, accessability for maintenance, location of suitable low resistance soil for the ground bed, permission of the land owner to install the unit, and location of other pipe lines in the area are the other main factors to be considered. Usually the final location decided upon is a compromise between the theoretically ideal and the practical.

In the application of cathodic protection there are many problems that arise that are often puzzling. Usually a person is in the habit of thinking of current as always flowing from positive to negative, which is natural, for most of our experience with electric circuits has to do with that portion where this is true. In any closed circuit, however, if current flows downhill in some parts, it must flow uphill in other parts in order to return to its starting point. Where it flows from positive to negative it is giving up energy; where it flows from negative to positive it is receiving energy or, in other words, it is being pumped uphill. This is in accordance with Kirchhoff's second law, which states in condensed form that "The total change of potential around any closed circuit is zero." It can be illustrated by plotting the potential changes from point to point around the circuit composed of a dry cell and a conductor connected across its terminals. For convenience suppose we letter the positive terminal A, the negative terminal B, the solution inside the cell adjacent to the zinc electrode C, and the solution adjacent to the carbon electrode D. Current is flowing through the external conductor from A to B and through the solution of the cell from C to D. Starting at A the current flows downhill to B through the external conductor; at the junction of the zinc electrode and the solution, energy is added and the current is forced to flow uphill from B to C; between C and D, through the solution, it again flows downhill; and at the junction between solution and carbon it is again forced uphill from D back to A, its starting point.

The galvanic cells on the surface of a pipe may be compared directly with the dry cell. The soil corresponds to the internal portion of the cell between C and D, the anodic areas correspond to the zinc, the cathodic areas to the carbon, and the steel of the pipe corresponds to the external conductor between A and B. In corrosion work, voltage measurements may be made anywhere in the circuit; sometimes with the voltmeter across the downhill portion, sometimes with it across the uphill portion. In fact, at times it will be across the uphill portion of one circuit and the downhill portion of another. When cathodic protection is applied to a line, a pipe-to-soil potential measurement is made with one terminal connected to the external portion and the other to the internal portion of the galvanic circuits on the pipe surface and, at the same time, both terminals are connected to points in the external circuit of the cathodic unit circuit.

Under these circumstances it is necessary for the investigator to juggle his thinking in order to picture himself at times outside a battery, inside a battery, or halfway in and halfway out. His correct interpretation of his measurements depends on his knowledge of where he is in the circuit or circuits he is dealing with.

In any cathodic protection installation we are dealing with a network of a large number of conducting paths with several voltages acting in the network. In addition to the voltage of the galvanic cells on the surface of the pipe forcing current out of the pipe at some points and back into the pipe at other points, we have the voltage of the cathodic unit forcing current to flow from the ground bed to the pipe through the earth, and the voltage of polarization at the pipe surface mentioned previously, which opposes any current being forced onto the pipe. The effect of any one voltage in any part of a network can be measured by removing that voltage without otherwise changing the network and observing the voltage changes that take place at the points in which we are interested. To observe the effect of the cathodic unit alone on the pipe-to-soil potentials, all we have to do is to connect a voltmeter between the pipe and reference electrode and observe the immediate change in voltage that occurs when the power to the cathodic unit is cut off or on. If we make this measurement at the point on the pipe nearest the ground bed the change will be a maximum. As we move along the pipe farther and farther away from the unit, the changes will become successively smaller until a point is reached where they are not discernable, and for all practical purposes are zero. Beyond these points, one in each direction from the unit, substantially no current from the unit reaches the pipe.

The length of pipe receiving current from the unit depends largely on the condition of the coating. Suppose the coating on our line is such that only a one mile section is receiving current directly from the unit; yet the pipe-to-soil potential measurements show that considerably more than a mile of the line is protected. This is not an unusual case but is in line with what should be expected. The reason is apparent when we consider the third voltage acting in the network, that is, the voltage of polarization at the surface of the pipe near the unit. In order to visualize how this acts, imagine that the one mile section that receives current from the unit is made of zinc instead of steel and that the cathodic unit does not exist. With this arrangement, current will flow from the zinc section to the steel pipe through the earth, and back along the pipe line, and in so doing will cathodically protect a certain amount of the steel pipe. According to Ohm's law the current that would flow would be proportional to the driving voltage and inversely proportional to the resistance of the circuit. Hence, the protective effect on remote parts of the pipe from this source is more pronounced where the circuit composed of the earth and the pipe line in series has a low resistance.

Now take out the zinc section of line and make it steel again and turn on the cathodic unit. Polarization of the steel pipe receiving current from the unit, due to that current, makes it look like zinc to more remote parts of the line, and like zinc it will protect a certain amount of the remote pipe. The action of the current from the unit is to maintain it in that anodic state and at the same time to prevent it from corroding by supplying it with more current than it discharges.

So far, this paper has considered only the effect of cathodic protection on the pipe line to which it is applied. Its effect on other pipe lines in the vicinity, not included in the protective scheme, may be injurious and must be considered in any cathodic protection project.

With respect to the cathodic unit, a foreign pipe line lying in the earth in the vicinity of the unit is simply a part of the earth and as such will serve as one of the many parallel paths to conduct current from the ground bed to the pipe under protection. At points where it picks

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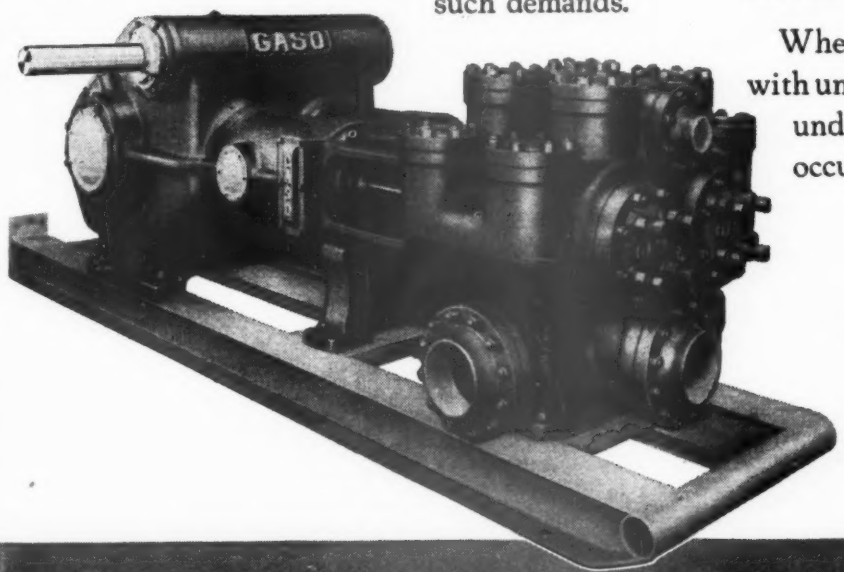

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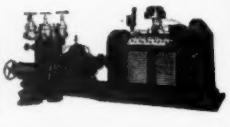

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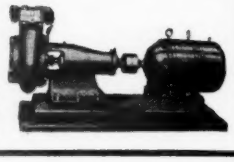

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up current corrosion will be reduced and at points where it discharges current corrosion will be increased. To determine at any given point whether it is collecting or discharging current from a particular cathodic unit it is only necessary to connect a voltmeter between the pipe and soil at that point and note the change in pipe to soil voltage as the unit is turned on and off, in the same way that the spread of current on the protected line was found. If the soil potential with respect to the foreign line goes more positive when the unit is turned on, some of the current from the unit is flowing onto the pipe at that point. If the soil potential moves in the negative direction, the opposite is true. The cathodic unit affects a foreign line only in so far as it affects the potential difference between the line and the surrounding earth.

A cathodic unit in operation forces the potential of the ground bed to shift in the positive direction and that of the pipe line in the negative direction. Each tries to pull the potential of the earth along with it but since they are pulling in opposite directions, their combined effect on remote points in the earth is zero. The potential of the earth relatively close to the units is distorted however. Points close to the ground bed are influenced more by the ground bed than by the pipe line, hence the net effect of the two is an increase in potential. Those close to the pipe line are affected more by the pipe, resulting in a net decrease in potential.

Let us suppose that a foreign line crosses the protected line somewhere well within the field of the cathodic unit, and that we measure the effect of the unit on its pipe-to-soil potential at various points. At a point remote from the protected line but as near as possible to the ground bed, the ground will swing more positive with respect to the pipe when the unit is turned on. As we move the voltmeter toward the protected line we eventually find a point where the pipe-to-soil potential is unaffected by the unit. Here the effect of the ground bed and the protected pipe line are exactly equal and opposite so there is no net discharge or collection of current. Moving still nearer the protected line, the soil potential begins to swing negative and reaches a maximum negative value at the crossing. The protected line also swings negative with respect to the foreign line. The customary procedure for relieving the exposure is to place a metallic bond between the two lines of such a resistance that the unprotected line is forced in the negative direction by the same amount that the soil is forced in that direction. This is usually done by the trial and error method. When the correct resistor is used there will be no change in the pipe-to-soil potential of the foreign line at the crossing when the cathodic unit is turned on and off. At all other points, the unit will cause the earth's potential to move in the positive direction with respect to the foreign line. After the correct bond is installed there will be a voltage difference between the two lines, with the protected line being negative to the foreign line. This is as it should be since the ground bed is positive to the foreign line and the combined effect of the ground bed and protected line on the unprotected line at the crossing is zero.

Ordinarily there is a galvanic voltage between any two pipe lines even when there is no outside influence such as a cathodic unit. A bond between the two closes the circuit of the galvanic cell to permit a current to flow, to the detriment of one, just as short circuiting a dry cell battery results in deterioration of the zinc. For this reason, cross bonds should be avoided except when necessary due to some outside influence. In general, when a cross bond is required, it should not have a lower resistance than necessary to accomplish its purpose. Often the effect of the protected line on the pipe-to-soil potential of the other line can be reduced by means of an extra heavy coating on the former for about 25 ft. each side of the crossing. The exposure being less, less current drainage is required and a higher resistance bond can be used.

When the foreign line lies outside the direct field of the cathodic unit but inside the field of the long line currents due to polarization established and maintained by the unit, the procedure in adjusting a cross bond is the same, except that when the unit is turned on or off, the resulting changes in pipe-to-soil potentials occur slowly.

Most of the electrical measurements in cathodic protection work are voltage measurements. The selection of an instrument for a particular voltage measurement depends on the characteristics of the circuit to which it is connected. Pipe-to-soil potentials using the copper sulphate electrode should be measured with a very high resistance or a potentiometer type instrument, which requires little or no current from the measured circuit. If any appreciable current is allowed to flow through the electrode it will polarize to some extent and its voltage will change. Other voltage measurements in which the copper sulphate electrode is not employed may be made with an indicating instrument such as the Weston Model 1 voltmeter. This instrument is particularly useful in measuring the voltage difference between two points on a pipe to determine the current flowing in the line and the changes in pipe-to-soil potentials due to turning a cathodic unit on and off. In the latter case, the potential of the reference electrode cancels out, so any convenient electrode, such as a steel bar, may be used to contact the earth. The correction necessary to compensate for the error introduced by resistance of the voltmeter circuit, external to the instrument, is:

$$\text{Open circuit voltage} = \text{voltage read} \times \frac{\text{Total circuit resistance}}{\text{Instrument resistance}}$$

This paper is rather brief for a subject of this nature. Some points have been touched on very lightly and others omitted entirely, but it is hoped that it will at least provide a fair picture of the fundamental factors involved. ★★★

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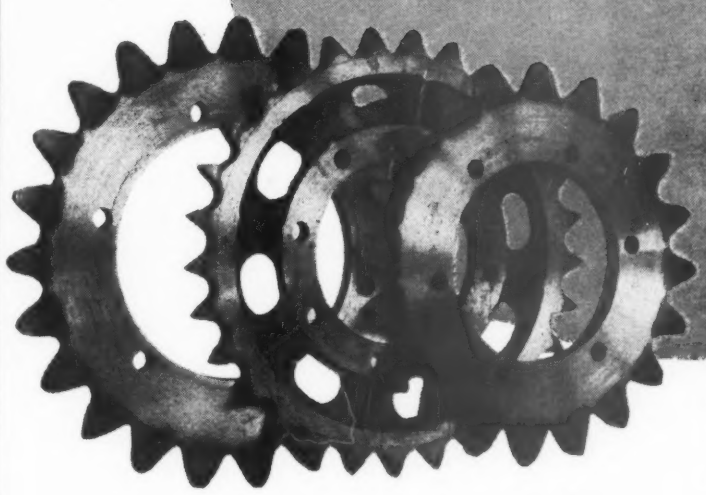

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Idle isomerization unit converted to produce polymer gasoline at low cost

By **W. R. NEWMAN,** *Vice President in Charge of Refining,* Frontier Refining Company

SUCCESSFUL conversion of a wartime butane isomerization unit to a non-selective catalytic polymerization unit has been accomplished by Frontier Refining Company of Cheyenne, Wyoming.

The cost was about $14,000. It was found necessary to install only one piece of new equipment to effect the change-over, which was engineered by Universal Oil Products Company. The job was done in about three weeks by the regular refinery force.

The converted unit has been operating for more than three months, producing 150-200 bbl. per day of 10 lb. RVP motor polymer, increasing the total gasoline production of the refinery by 5 to 7 per cent and effecting substantial savings in the amount of tetraethyl lead needed to bring the regular and premium grades of Frontier gasoline to the required octane rating.

The No. 2 refinery in which the conversion was made is an aviation gasoline plant built in 1943 for the Defense Plant Corporation. It consists of a crude unit of 3200 bbl. per day capacity, a thermal reforming unit, a fluid catalytic cracking unit with design capacity of 2600 bbl. per day (the smallest commercial unit in the world), a gas concentration system, a UOP hydrogen fluoride alkylation unit, a UOP isomerization unit, and a treating plant.

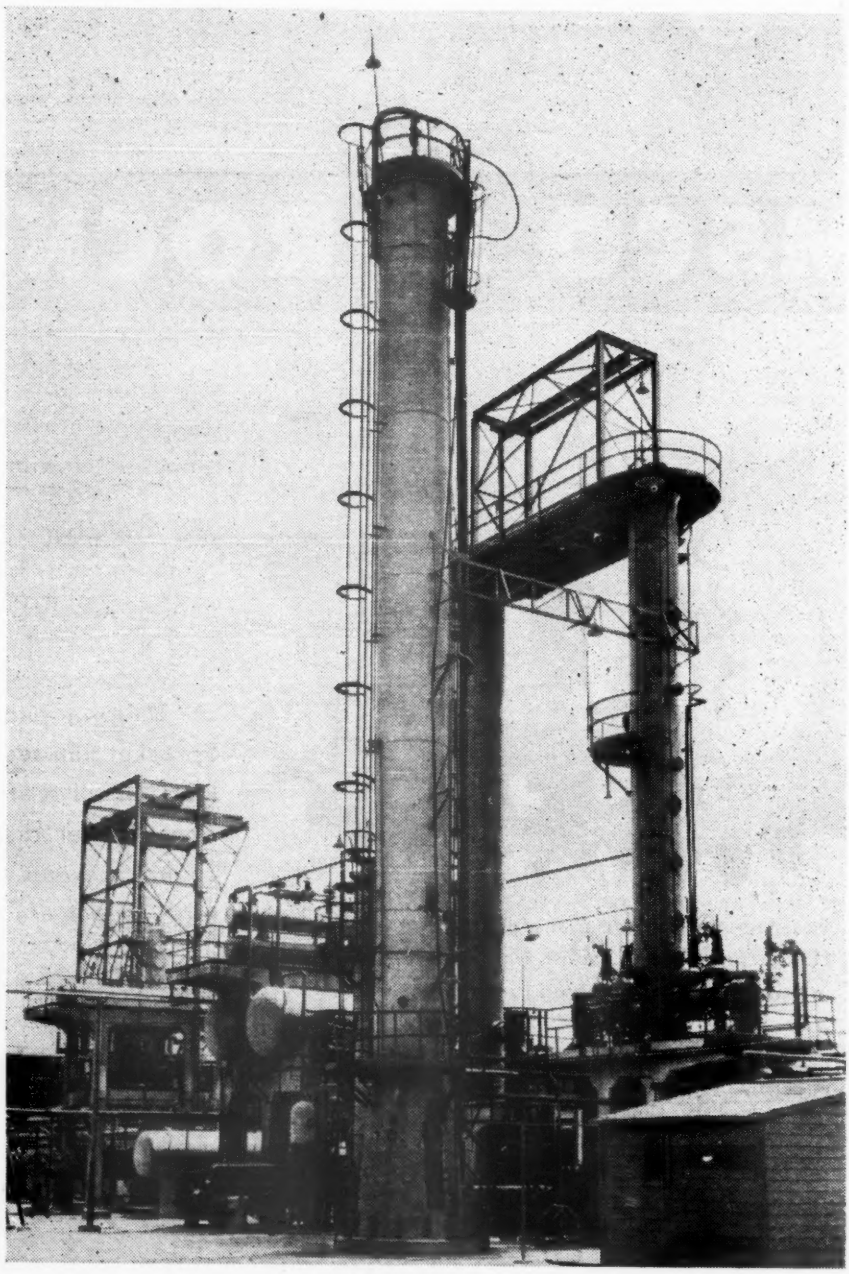
When the aviation gasoline refinery was built, it was interconnected by pipe lines to No. 1 refinery, about 500 yards away, to permit interchange of raw materials and products. No. 1 plant, which was built in 1941, consists of a topping unit with charging capacity of 4500 bbl. per day, a UOP thermal cracker, capacity 700 bbl. per day, an asphalt unit, and lube oil blending facilities. It operates on Elk Basin (Wyoming) crude, a black oil of 28 API gravity and containing about 2.3 per cent sulphur.

Having in the two refineries all the equipment needed to make the various components of 100-octane gasoline, Frontier was a consistent producer of finished fighting aviation motor fuel until the nation's need for this special product ceased.

As operated during the war, gas oil from the topping unit in Refinery No. 1 was piped to the government-owned plant, where it was added to the gas oil produced in the topping unit of Refinery No. 2 and fed to the catalytic cracking unit. The cracked gases from the thermal cracking unit were fed into the gas concentration unit with the liquid and gas products from the catalytic cracker, for the purpose of recovering light hydrocarbon fractions to be used as feed for the alkylation unit.

When the war ended, Frontier, like other refiners, was eager to convert as speedily as possible to the manufacture of products it could make to the best advantage for civilian markets. Therefore, it was decided to continue to increase the production of higher grade motor gasoline and at the same time to develop a market for bottled gas that would offer an outlet for the C_3-C_4 fractions.

View of former isomerization reactor, the lower portion of which now contains solid phosphoric acid polymerization catalyst.



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Canada crude higher

An increase of 50 cents a barrel in the price of Turner Valley crude was announced in Canada recently. The new price for 42 gravity crude will be $2.65 a barrel at the wellhead with same gravity differential scale of 2 cents a degree as at present. The increase in domestic crude prices came two days after removal of the subsidy on crude imported from U. S. Producers will probably benefit by an additional $2,500,000 in 1947 as a result of the 50-cent price increase.

With these objectives in mind, the company leased the facilities of Refinery No. 2 from the government. Of these facilities it was intended at first to operate only the fluid catalytic cracking unit and the gas concentration unit, the former to make cracked gasoline of superior quality and the latter to stabilize the gasoline and to recover the maximum of C_3-C_4 for bottled gas.

The Frontier management asked Universal to make a study of the gas concentration system with a view to simplifying it and reducing operating costs, and to consider the entire refinery picture as well.

The study disclosed two things:

First, that the cost of operating the existing gas concentration system was very little greater than the cost of operating a simple absorber-stabilizer system, and it had the advantage of recovering the maximum of light hydrocarbons.

Second, that because of the growing market for gasoline and acceptance of the Frontier product, the light fractions could be converted to polymer gasoline more advantageously than they could be marketed as bottled gas.

A review of the equipment available at the idle alkylation and isomerization units disclosed that a large portion of the equipment in the latter could readily be converted to a polymerization unit. It appeared that the conversion would be simple, requiring few piping changes or additions of equipment.

The additional equipment specified for the conversion consisted of three G-fins to afford more surface for heating the feed to the poly reactor, two water-injection pumps for the maintaining of proper catalyst hydration, and a new filter pot for collecting the small amount of catalyst fines liberated when new catalyst is placed on stream.

Actually, the filter pot, a vessel of 24 in. ID, 5 ft. high and suitable for 500-lb. pressure, was the only piece of new equipment that had to be installed. The other miscellaneous items required were available in the refinery. Two existing caustic feed pumps were rebored and new trim was added for the new water injection service.

Conversion of the reactor tower of the isomerization unit to serve as the catalyst tower for the polymerization unit was a simple matter, requiring only the fitting of a grating in order to make it possible to separate the polymerization catalyst into two 7-ft. beds. Connections were added to the tower to permit introduction of a quench stream and water injection between catalyst beds. Four thermocouples were installed for the purpose of measuring catalyst temperatures.

Because of the high sulphur content of the crude processed at Frontier, the light fractions produced in cracking the topped crude and gas oil are high in hydrogen sulphide and mercaptans. Consequently, it becomes necessary to remove the sulphur compounds from the poly plant feed as they would otherwise become concentrated in the polymer, thereby reducing its blending value.

The sulphur content of the C_3-C_4 fraction when operating the gas concentration unit for maximum recovery of propylene and butylenes was known to be of the order of 1500 grams of combined H_2S and mercaptans per 100 cu. ft. This sulphur content can be held down to approximately 100 grams per 100 cu. ft. by operating the deethanizer and other columns under conditions that give less than maximum recovery of propylene.

The use of a regenerative type H_2S removal system was given consideration as a means for obtaining removal of a major portion of the sulphur compounds from the poly plant feed. Making provision for such facilities, however, would have delayed the start-up of the poly unit and would have increased the cost of making the conversion. It was decided therefore to start the operation in such a manner that the gas concentration unit would reject the bulk of the H_2S and mercaptans from the poly plant feed, postponing the installation of a regenerative type H_2S removal system.

Following is a general summary of the manner in which the gas produced in the catalytic cracker is handled through the gas concentration and polymerization units.

The cracked gasoline and gases from the catalytic cracking unit are fed into the gasoline stripper of the gas concentration system, the bottoms from which is used as absorption oil in the deethanizer into which passes the gaseous and liquid overhead from the gasoline stripper. The deethanizer now, as before, is operated to remove all gases lighter than the propane-propylene fraction.

The deethanizer bottoms stream is sent to the former depentanizer, which now acts as a debutanizer to separate the C_3-C_4 fraction from the catalytically cracked gasoline. A low vapor pressure gasoline is produced as bottoms from this column in order to recover all possible of the C_4 fraction for polymerization plant feed.

The liquid C_3-C_4 fraction obtained as a net overhead stream from the gas concentration unit depentanizer is pumped through a caustic wash on its way to the polymerization unit for the removal of H_2S and mercaptans. Thus is produced a low sulphur polymer having optimum blending octane number.

TABLE 1

Fractional distillation analyses of feed and products at the polymerization unit.

	Fresh feed, mol. per cent	Recycle, mol. per cent	Polymer, liquid vol., per cent
Propylene	15.7	0.5	
Propane	14.1	36.3	
Isobutane	21.8	46.7	10.4
Butylenes	36.2	2.2	2.4
Normal butane	12.2	14.3	11.9
Isopentane	0	0	1.0
Normal pentane			1.8
Hexane+			72.5
Sp. gr.			0.7015
Olefin content	51.9	2.7	
R.V.P.			23.3
E.P.			417°F.

The fresh C_3-C_4 feed is collected in a combined feed surge drum where it is mixed with a low olefin content recycle stream from the polymer stabilizer overhead. The recycle stream is used to dilute the olefin content of the feed to the catalyst tower so that the temperature rise occurring in the catalyst beds, as a result of the exothermic polymerization reaction, will not be excessive. Typical analyses of the fresh feed and recycle are shown in Table 1.

The fresh feed normally contains 45-50 per cent C_3 and C_4 olefins. Sufficient recycle is used to obtain a combined feed having an olefin content of approximately 20-22 per cent.

The combined feed is then pumped through an exchanger to recover the heat from the catalyst tower effluent, through a pre-heater, and then into the catalyst tower. The temperature of the feed to the catalyst tower is controlled to give the desired degree of olefin conversion without exceeding a maximum of 450 F. at any point in the catalyst beds.

Under normal operating conditions when processing a 20 per cent olefin content combined feed the temperature in the catalyst beds will range from 350-380 F. inlet to 430-450 F. outlet.

The conversion of olefins obtained at these temperatures has been of the order of 90-95 per cent.

Effluent from the catalyst tower is fed to the column, which was formerly used for aluminum chloride recovery in the isomerization process but is now used as a polymer stabilizer. The net overhead from this stabilizer is released to the fuel system. The condensable portion of the polymer stabilizer overhead stream is used for reflux as well as recycle.

The bottom fraction from the polymer stabilizer is high vapor pressure polymer, which is blended directly with the catalytically cracked gasoline. Sufficient butanes are retained in the polymer to control the vapor pressure of the total gasoline make of No. 2 refinery.

Thus, the Frontier polymerization unit is producing on an average of 150 to 200 bbl. daily of 10-lb. Reid vapor pressure polymer gasoline having a ASTM octane rating of 81-83 and a research octane rating of 95-97.

A typical analysis of the product from the polymerization unit is shown in Table 1. ★★★

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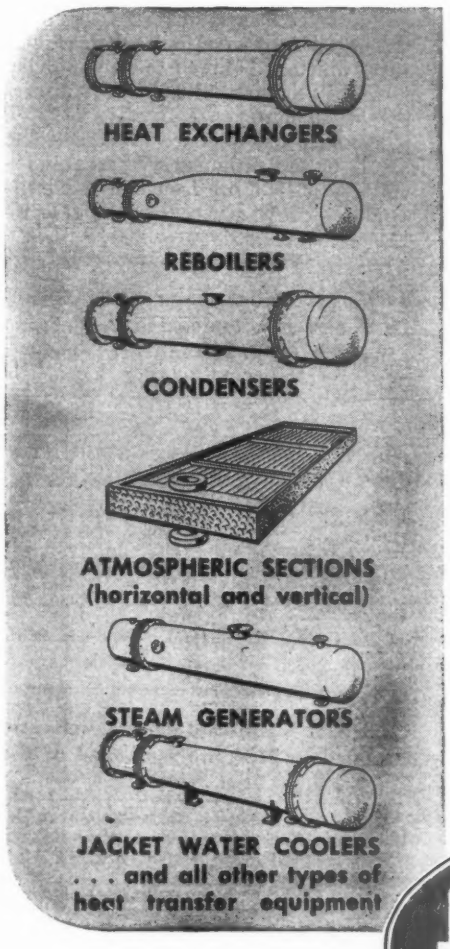

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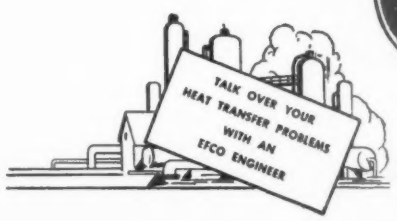

Unitization program for West Cement Medrano

By **K. MARSHALL FAGIN,** *Field Editor*

EXCLUSIVE

THE presentation of a plan for the unitized management, operation, and further development of the Medrano sand pool in the West Cement field of Caddo County, Oklahoma, marks a great forward step in the conservation of oil and gas in the state.

It is the first such plan to be presented to the Corporation Commission under the relatively new unitization law, House Bill 339 of the 1945 Legislature of the State of Oklahoma. Its proponents, Amerada Petroleum Corporation, Anderson-Prichard Oil Corporation, Phillips Petroleum Company, Ray Stephens, Inc., Stephens Petroleum Company, and Magnolia Petroleum Company, supplied expert testimony at the first hearing in December, 1946, showing that future production from this reservoir may be increased by 8 to 40 million bbl through adoption of the unitization program.

● **Further hearing to be held this month.** Due to a crowded docket the Corporation Commission has postponed further hearing on this unitization plan until February 25 to 28, 1947, inclusive. Fig. 1 shows a map of the field and the area that the companies desire to unitize (outlined by a hatched line). This unit area includes the 1980-acre gas cap and the 1300-acre oil productive area of the Medrano sand pool, and contains 72 separate leases owned by 13 companies and individuals.

Three of the 36 wells that produce from the oil bearing part of the Medrano reservoir are given gas well allowables by the Commission; two of the oil wells are penalized because of high gas-oil ratios; eight of the oil wells are unable to produce the 200 bbl daily allowable granted to oil wells during January, 1947, and three are not listed on the schedules.

● **Many tracts not drilled.** The gas cap part of the Medrano reservoir is developed with 21 gas wells, making a total of 57 wells on the 72 separate lease tracts, but 33 of the tracts are not drilled at the present time although wholly or partly covering a portion of the Medrano oil or gas-bearing reservoir, and it is doubtful that many of these provide drilling sites that are economically feasible under either present or unitized drilling and production conditions.

Under present conditions, the owners of most of these edge leases would be unable to profit by drilling wells to the Medrano reservoir, but under the proposed plan for unitization all owners will have a reasonably proportionate share in the profits of the unitized operations.

The operators and royalty owners of producing tracts are not, however, sharing the profits from their production with the owners of edge properties. They are simply acknowledging the possibility of recovering a little of the small quantity of oil and gas that may underlie the edge properties, and they recognize the possibility of making greater profits for themselves through the additional freedom of operations that acquisition of the edge properties will give the unit.

Although all the operators of wells in the Medrano sand pool may accept a Corporation Commission finding that the proposed unitization plan is fair, reasonable, equitable, and in the interest of conservation, it is probable that one or more of the landowners or royalty owners will seek relief from "forced" unitization under the new law and thus provide a court test of the authority of the commission to promulgate a unitization order.

● **Production, factual data, and recovery estimates.** Table 1 shows the daily average crude oil runs from the West Cement Medrano oil wells by months since the discovery of oil on the south flank of the gas cap in March, 1943. Most of the fluctuations in runs have been caused by changes in the allowable production and the completion of additional wells.

Table 2 summarizes some of the important facts and statistics concerning the wells, the reservoir, and the production of oil and gas. Table 3 presents estimates of the extent of the Medrano sand oil and gas reservoir, the quantities of oil and gas originally in place, and the percentage recovered. It should be emphasized that the gas and oil estimated to have been in the reservoir originally is not all recoverable.

● **Unit plan would cut gas production.** The ultimate recovery of gas from the Medrano pool will not be materially changed by unit operation, but the gas wells will be closed in and the bulk of the gas will not be produced until after most of the oil wells have been exhausted. Income from the sale of gas, will be deferred, therefore, until oil production becomes insignificant.

The ultimate production of oil will be increased considerably, however, by unit operation. The quantity of additional production that may be obtained by unit operation depends upon the effectiveness of the proposed pressure maintenance program and any other recovery methods that may be introduced such as water flooding.

Present operating methods are expected to result in the recovery of only 20,500,000 bbl. This would be about 165 bbl per acre-ft, or 19 per cent of the estimated total stock tank oil in place (see Table 3). Unit operation is expected to result in the ultimate recovery of 28,500,000 bbl by simply closing in the gas wells and producing oil through the low gas-oil ratio wells.

● **Unitized operations could minimize underground waste.** This would represent an increase of 8,000,000 bbl, or 40 per cent more oil than is expected by present operations. Part of this increase would be due to the prevention of oil migration or coning into the dry sand in the gas cap, where it would be left unrecoverable in the form of a film or coating on the sand grains or as droplets in the pores. The rest of the increase (about 5,000,000 bbl) would be due to the greater effectiveness of the gas cap drive through the conservation of the gas pressure, which is believed to be supplying almost all the natural energy that causes the oil to flow.

Pressure maintenance is expected to result in the ultimate recovery of 34,000,000 bbl of oil from the Medrano sand pool, if 60 per cent of the gas pro-

TABLE 1. Daily average crude oil runs from oil wells completed in the Medrano sand reservoir of the West Cement field, bbl.

Month	1943	1944	1945	1946
January	....	3673	6735	7470
February	....	4332	6951	7369
March	383	4886	7219	3861
April	361	5712	7435	4500
May	653	5748	7258	4854
June	877	6000	7463	5444
July	1260	6140	7296	5505
August	1532	6147	7791	5170
September	1843	6092	7675	5022
October	1886	6560	7248	5203
November	2576	6303	7325	5075
December	3271	6719	7254	5162

TABLE 2. Significant data on wells and production, Medrano sand pool of the West Cement field.

Discovery: (a) gas—Magnolia's Medrano No. 6—October 1936. (b)-Oil—Stephen's Pierson No. 1—March 1943.

Well depths: (a) Average—6000 ft. (b) Range—4350 ft to 6280 ft.

Structure: Flank type, dipping southward about 30 ft per 100 ft and wedging out updip against main fault and truncation.

Sand: Medrano sand, Pennsylvanian Age, fairly clean, without shale breaks, and relatively uniform permeability and porosity.

Number of wells: (a) Producing oil—January 1, 1947—36. (b) Producing gas—January 1, 1947—21. Total—January 1, 1947—57.

Cumulative production: (a) Gas as of January 1, 1947—70 billion cu. ft. (b) Oil as of January 1, 1947—7,170,000 bbl.

Present daily production: (a) Gas, January 1947—23 million cu ft. (b) Oil, January 1947—5,000 bbl.

Gravity of crude oil: 36 to 38 deg. API.

Gravity of gas: 0.59 to 0.61.

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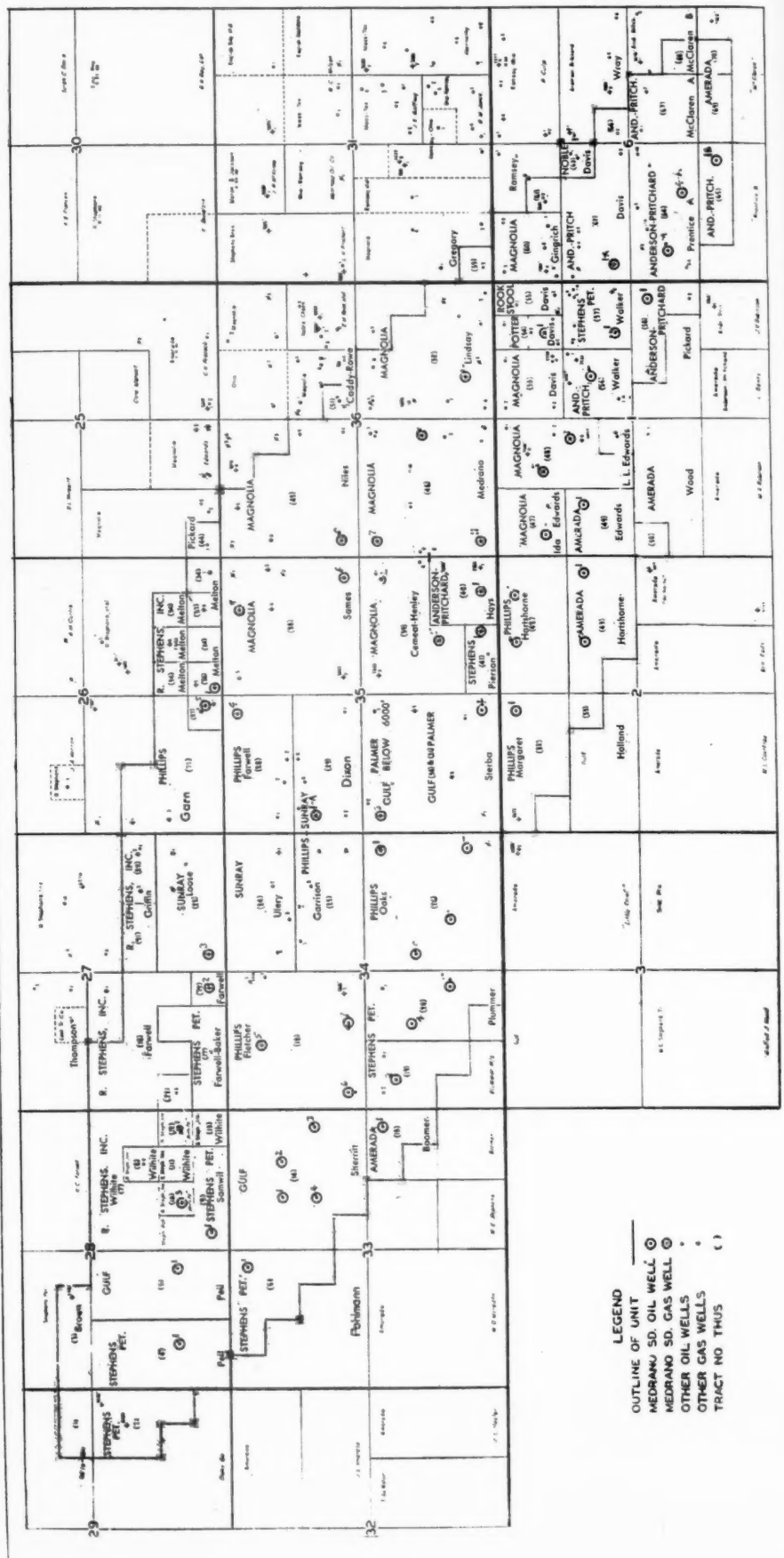
MAP OF WEST CEMENT MEDRANO UNIT.



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duced with the oil is returned to the gas cap, or 38,500,000 bbl if 80 per cent is returned. It is obvious that relatively small differences in the amount of gas returned to the gas cap will have an important bearing on the ultimate production of oil and effectiveness of a pressure maintenance program.

A recovery of 34,000,000 bbl would represent an increase of 5,500,000 bbl due to the return of 60 per cent of the gas produced with the oil, and would be 31.5 per cent of the oil in place, or a recovery of 275 bbl per acre-ft.

A recovery of 38,500,000 bbl by return of 80 per cent of the gas would represent an increase of 4,500,000 bbl more, and amount to 35.5 per cent of the oil in place, or 310 bbl per acre-ft.

● **Water injection offers additional recovery.** As for the possibility of introducing an artificial water drive by injecting water into the reservoir near the oil-water contact, it is estimated that the recovery of an additional 15 or 20 million bbl of oil would result, but whether or not such an operation would be economically feasible is difficult to determine at the present time.

The fact remains that several million barrels of crude petroleum that would be recoverable under unitized operations will be left in the Medrano sand reservoir when the wells are abandoned unless a plan for unitization is approved by the Corporation Commission, upheld by the courts, and wisely followed by the operators.

TABLE 3. Estimates of Medrano sand reservoir volume and oil and gas recovery, West Cement field.

Proved area: (a) Gas zone—1980 acres. (b) Oil zone—1300 acres. Total oil and gas—3280 acres.

Average thickness: (a) Gas zone 65 ft. (b) Oil zone 96 ft.

Proved acre-ft.: (a) Gas zone—130,000. (b) Oil zone, 124,000.

Average porosity: 16.5 per cent of sand volume, or 1280 bbl per acre-ft.

Average connate water: 20 per cent of pore space, or 256 bbl per acre-ft.

Average oil shrinkage: 15 per cent (due to reduction in temperature from reservoir (116 F) to stock tank (60 F), and loss of dissolved gas (420 cu ft per bbl.)

Stock tank oil originally in place: 870 bbl per acre-ft, or 108,000,000 bbl.

Gas originally in place in gas zone: 130 billion cu ft.

Gas originally dissolved in crude oil: 46 billion cu ft.

Cumulative per acre-ft (January 1, 1947): (a) Gas—540 cu ft. (b) Oil—58 bbl.

Recovery as of January 1, 1947: (a) Gas—40 per cent of original. (b) Oil—6.6 per cent of original.

● **Essence of the proposed unit plan.** The plan of unitization proposed by the operators is the result of more than a year's work by the operators and joint engineering, accounting, and geological committees. It contains 27 separate sections detailing the steps that will be taken by the operators when and if the plan is approved by the commission, and it contains four exhibits: "A," a map of the unit area; "B," percentages of interest in the unit and special provisions with respect to the allocation of unit production; "C," an outline of unit accounting procedure, and "D," a table of well values.

All operations in the Medrano pool will be vested in an operating committee consisting of the lessee or one representative of each lessee in the unit area. This operating committee will direct all unit operations through "the unit operator," which is designated as Phillips Petroleum Company, but will have the power and duty to remove and replace "the unit operator" with another interested company, if such eventuality should be deemed necessary, or when the operating committee decides that the unit should be dissolved.

Section XV details the plan of operation, but the execution of the various plans hinges largely upon the approval and final judgment of the operating committee.

The special provisions with respect to allocation of unit production provide for maintaining the current income of some of the companies for the next few years, but excess payments to them in the first period will be deducted from their income during a second period. The apparent agreement of all the operators is a tribute to who that have labored on this plan to unitize and thus increase the ultimate recovery of oil from this pool. It is to be hoped that the commission will approve the plan in the interest of conservation, and that the courts will uphold it.

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Evaluation of sulphur compounds in gasoline

By **F. C. MORIARTY,** Universal Oil Products Company

During the years prior to the war, there was an almost continual increase in octane number requirements, and it is expected that this increase will continue in postwar years. As higher octane levels are reached, incremental increases become more difficult to obtain. If these incremental increases could be evaluated in dollars, we would find them expensive indeed. In the prewar period, there were many who suggested that each refiner should carefully analyze his treating processes with a view to improving octane number or eliminating octane losses. At today's high octane levels, these suggestions seem more pertinent than ever. Many refiners may have valuable untapped resources in their treating plants that, if utilized, will postpone the day when it becomes necessary to make extremely expensive changes to the refinery processing units.

The treatment of gasolines produced from high sulphur crudes has always presented a serious problem and merits careful study. Many refiners who in the past have processed sweet crudes, are now faced with the importation of high sulphur crudes, as our largest reserves and newest crude discoveries are high in sulphur. For this reason, there are few refiners today who are not either charging high sulphur crudes, or making plans to process such crudes in the future.

In order to attack refinery treating problems intelligently, it is necessary to study first the individual types of compounds present in the raw untreated products. It is the purpose of this article to present an evaluation of the sulphur compounds in gasoline and a basis for establishing sulphur treating procedures.

A laboratory report, listing only "total sulphur" is of little use in reaching an intelligent decision involving treating matters, yet total sulphur is frequently the only analysis available. There are many sulphur compounds in gasolines, and they have widely divergent chemical properties. Some of the sulphur compounds are acidic, some corrosive, and some are harmful to octane number.

A complete and detailed laboratory analysis for sulphur compounds is most time consuming and, therefore, not practical for use in any but research programs. For practical purposes, it is possible to simplify the analytical procedure. For straight-run gasolines, hydrogen sulphide, mercaptan and total sulphur determinations are required and these are easily determined in the laboratory. In addition, it is usually worthwhile to make a laboratory catalytic desulphurization test, the purpose of which will be explained later.

For cracked gasolines, it is sufficient to determine the hydrogen sulphide, mercaptan and total sulphur content. If the foregoing determinations are made, it is not difficult to choose a proper treating procedure or to determine, within rather close limits, what improvements can be made to existing facilities.

Generally speaking, there are three reasons for reducing the sulphur content of gasoline: To improve odor, to meet specifications limiting total sulphur, and to improve certain properties of the gasoline, particularly tetraethyl lead susceptibility.

The various sulphur compounds in gasoline fall generally into three groups:

Group 1. Those which exhibit acidic properties, hydrogen sulphide and mercaptans.

Group 2. Neutral, but thermally unstable, sulphur compounds, mono and disulphides.

Group 3. Thermally stable sulphur compounds, cyclic compounds, such as thiophenes.

Group 1 sulphur compounds, hydrogen sulphide and mercaptans, can be determined directly in the laboratory.

If straight-run gasolines are catalytically desulphurized, Group 2 compounds, which are thermally unstable, will be decomposed to hydrogen sulphide, and in this manner, the Group 2 sulphur content of straight-run gasoline can be determined. Any remaining sulphur can be classified as Group 3, although straight-run gasolines do not normally contain appreciable quantities of the compounds in Group 3.

In fresh, that is to say unoxidized, samples of cracked gasoline, sulphur compounds will be predominantly those of Group 1 and 3, or hydrogen sulphide, light mercaptans, and cyclic sulphur compounds. As Group 2 is usually not present in appreciable quantities, in raw cracked gasoline, Group 3 can be determined by difference, assuming the hydrogen sulphide and mercaptan content is known. The absence of Group 2 compounds in cracked gasoline can probably be explained by the fact that these are thermally unstable. If originally present in the charging stock, they would have been changed under the high temperature conditions of the cracking process to form sulphur compounds of Groups 1 or 3. In fact, Group 3 sulphur compounds seem to be associated principally with cracked products.

After the above classifications have been made in terms of actual percentages, for both cracked and straight-run gasolines, it becomes a simple matter to choose a process suited to the individual gasoline.

Sulphur compounds, which fall in Groups 1 and 2, are extremely harmful to tetraethyl lead susceptibility. If these groups are present in significant quantities, their removal is always desirable. The sulphur compounds that fall in Group 3 are not appreciably harmful to tetraethyl lead susceptibility, and their removal is not justified unless it is necessary to meet specifications that limit total sulphur.

Hydrogen sulphur must be removed from motor fuels because it is corrosive. Fortunately, hydrogen sulphide has acidic properties and is easily removed, either by simple caustic washing, or by some process involving a weak alkaline reagent that can be regenerated, such as the Girbotol or Shell T.P.P. processes. The end product of the reaction of hydrogen sulphide with caustic soda is sodium acid sulphide, which cannot be regenerated by simple means. If hydrogen sulphide is present in small quantities, caustic washing is usually employed as caustic consumption will not be great, and small quantities of waste caustic do not usually require difficult methods of disposal. If hydrogen sulphide is present in higher concentrations, it may be necessary to use one of the patented processes involving reagents that can be regenerated in order to prevent a serious disposal problem and to reduce cost.

It is also possible to remove hydrogen sulphide by fractionation, although sometimes this is not desirable, because of the hydrocarbon losses that accompany this type of hydrogen sulphide removal. The economics involving hydrogen sulphide removal by fractionation are rather straight-forward, and if an analysis of light hydrocarbon fractions, together with hydrogen sulphide, is available, calculations can be made to determine equipment requirements and expected hydrocarbon losses. An economic comparison with other methods is then possible.

Mercaptans are weak acids, making possible their extraction from gasoline by aqueous alkaline reagents. They are malodorous sulphur compounds and must be removed from gasolines if present in significant quantities. Mercaptans can be converted to comparatively nonodorous disulphides by oxidation and processes that accomplish this are known as sweetening processes. Doctor and copper sweetening units are examples. Conversion to disulphides in these processes is not accompanied by desulphurization as the disulphides that are formed remain in the gasoline. Mercaptan extraction is accompanied by an octane gain, because sulphur is actually removed from the gasoline. Sweetening processes, on the other hand, produce an octane loss as no sulphur is removed and the disulphides that are formed are some-

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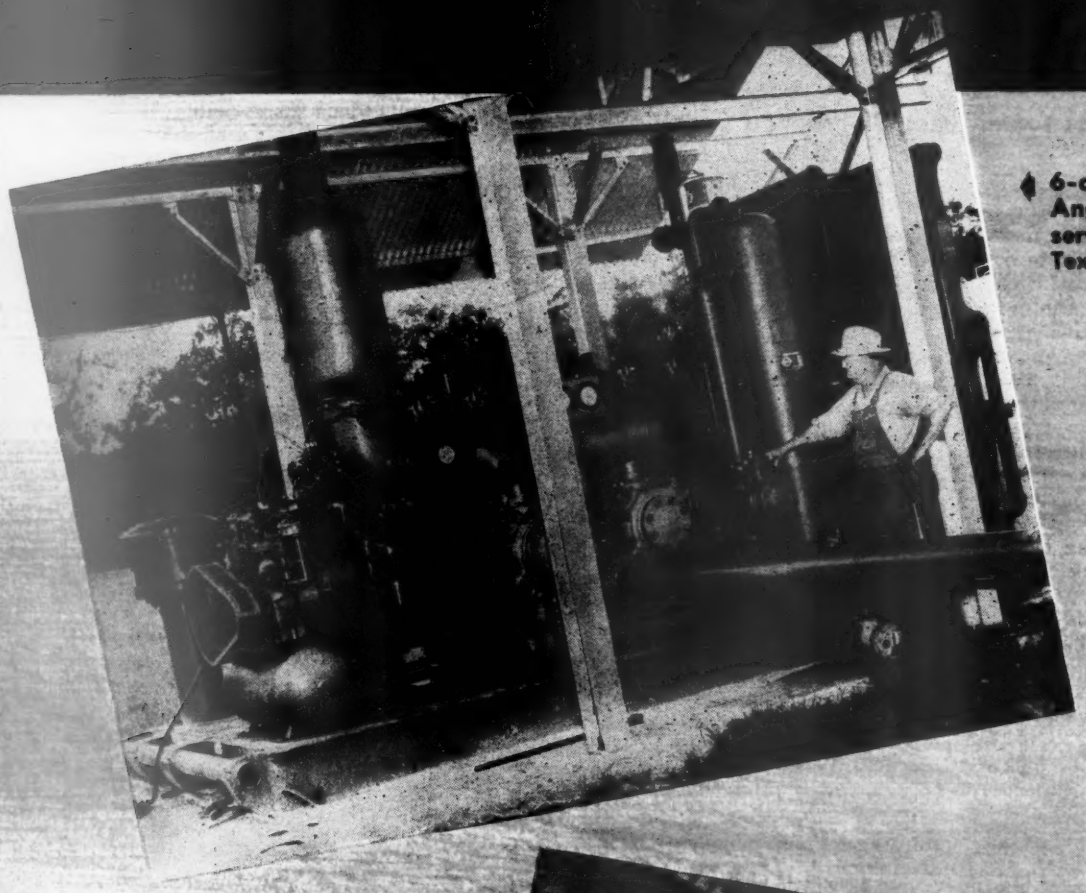

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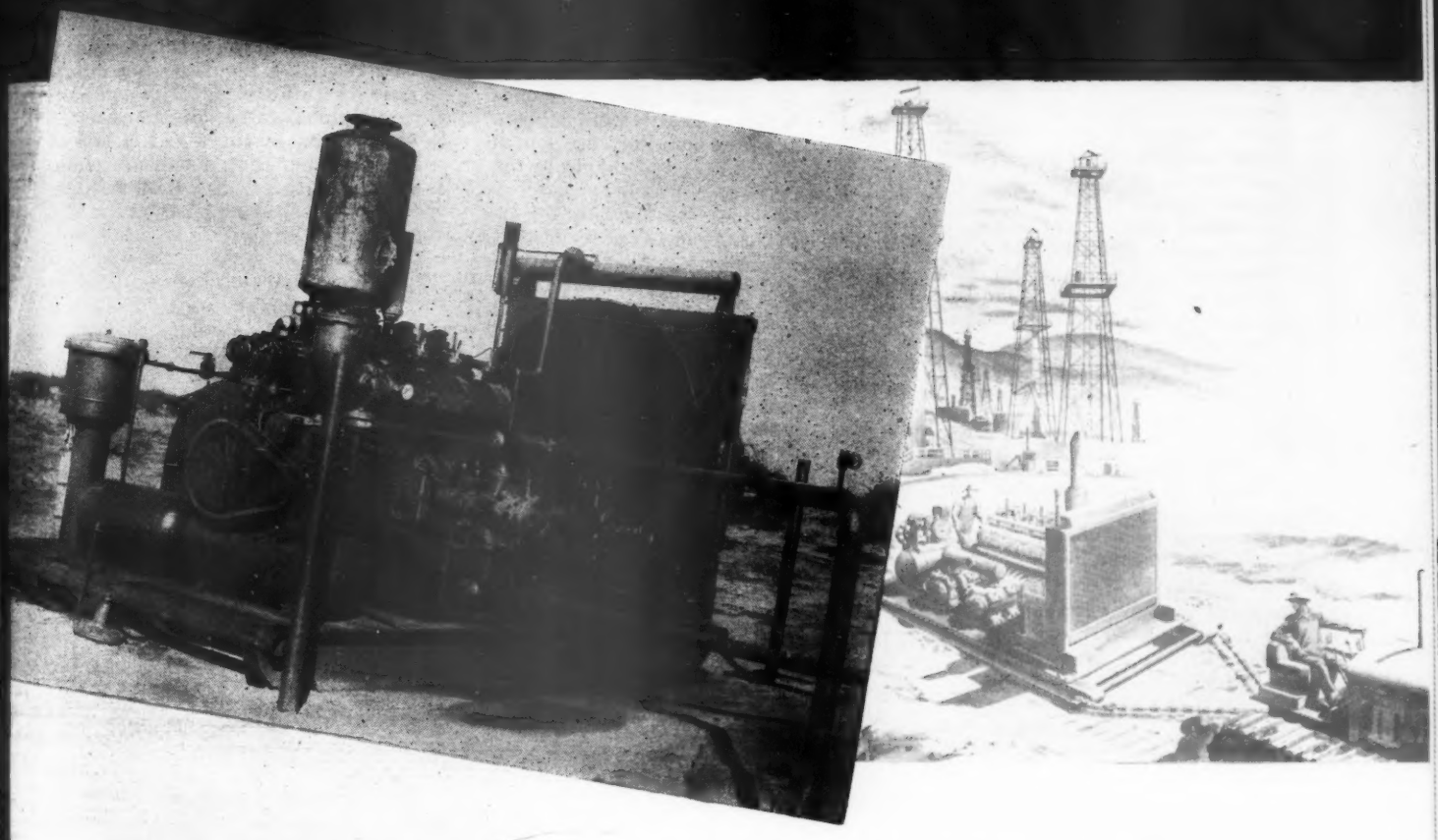

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what more deleterious to octane than the mercaptans originally present.

In cracked gasolines, if the mercaptan content is known, it is a simple matter to choose the proper type of process. If the mercaptan concentration is below 0.004 weight per cent, it has been demonstrated that odor will not be a problem and further processing is not necessary, unless required to meet an arbitrary specification requiring a negative doctor test. If the mercaptan concentration of the untreated gasoline is above 0.004 per cent and below 0.02 per cent, it is usually possible to produce a satisfactory product with a continuous regenerative caustic scrubbing unit, for this method will ordinarily extract from 75 to 80 per cent of the mercaptan sulphur present. Such sulphur removal will be accompanied by a slight increase in octane number.

Mercaptan contents above 0.02 weight per cent are most satisfactorily treated by one of the newer mercaptan extraction processes, such as the Unisol process, as these will remove substantially all the mercaptan present and produce an octane improvement that at the 3 cc lead level often amounts to as much as 3 full numbers.

Sweetening processes are only recommended for gasolines extremely low in mercaptan sulphur, in those areas where a strict interpretation of the doctor test is required. Sweetening processes that result in a loss in octane number, rather than improvement, are always a burden and expense to the refiner; whereas sulphur removal processes will usually more than pay their own way.

As cracked gasolines contain little or no Group 2 sulphur compounds, sulphides and disulphides, any sulphur remaining, after mercaptan and hydrogen sulphide removal, is usually in the form of cyclic sulphur compounds. Cyclic sulphur compounds are not particularly deleterious to octane number and, therefore, can be permitted to remain in the gasoline, unless removal is necessary due to a specification limiting total sulphur. After hydrogen sulphide and mercaptan removal from cracked gasolines, further desulphurization cannot be economically justified and will not result in an advantage to the ultimate consumer. Unreasonably low total sulphur specifications, which may require cyclic sulphur removal, are an unwarranted burden on the refiner. The process used for cyclic sulphur removal is usually treatment with sulphuric acid, a costly and wasteful process.

Assuming that hydrogen sulphide and mercaptan removal has been accomplished, any additional octane improvement on cracked gasoline must come from a hydrocarbon conversion process or a change from thermal to catalytic cracking, which considerations are outside the scope of this article.

To summarize, for treating cracked gasolines, some form of mercaptan extraction, either caustic scrubbing, or processes such as Unisol are recommended. Sweetening processes are never recommended, except where the initial mercaptan content is very low and a negative doctor test is required.

Straight-run gasolines contain, in addition to hydrogen sulphide and mercaptan, Group 2 sulphur compounds, which are designated as being thermally unstable, such as sulphides and disulphides. A decision concerning the treatment of straight-run gasoline depends upon the relative proportions of mercaptans and Group 2 sulphur compounds and the amount of total sulphur present. Many straight-run gasolines are low in total sulphur content and cannot be appreciably improved by catalytic desulphurization. These may contain, for example, mercaptans in the order of 0.01 weight per cent or less. Catalytic desulphurization processes usually cost between 8 and 15 cents per bbl. to operate on straight-run gasolines. If it has been determined that the octane improvement from catalytic desulphurization cannot justify this expense on a low sulphur straight-run gasoline, it is usually recommended that the gasoline be either caustic washed with a regenerated caustic process to below 0.004 weight per cent mercaptan sulphur or, if the doctor specification is necessary, that it be sweetened with a copper or doctor process. For higher sulphur straight-run gasolines, it is recommended that catalytic desulphurization, such as the Gray high temperature clay treating process, be used.

Catalytic desulphurization on straight-run gasolines will usually show a marked improvement over mercaptan extraction methods, because catalytic desulphurization will remove both mercaptans and Group 2 sulphur compounds. As straight-run gasolines seldom contain appreciable quantities of Group 3 sulphur compounds, when catalytic desulphurization is used, sulphur removal is almost complete, and an appreciable octane improvement will usually result.

By comparison, this process is not economically sound for use on cracked gasolines. The reason for this is that fresh, untreated cracked gasolines usually contain only mercaptans and relatively thermally stable cyclic sulphur compounds such as thiophene. The cyclic sulpnur compounds are not decomposed by catalytic desulphurization, whereas the mercaptans can be removed by either catalytic desulphurization, or by the less costly mercaptan extraction processes. As the amount of sulphur that can be removed from cracked gasolines is approximately equal for both catalytic desulphurization and mercaptan extraction, the octane improvement that follows is almost the same in either case, and the less costly of the two processes is recommended. For the treatment of cracked gasolines, the extraction processes have other advantages over catalytic desulphurization. The effective life of desulphurization catalysts, when processing cracked gasolines, is short, due to carbon deposition, and, therefore, it is necessary to resort to frequent regeneration, which adds materially to the operating cost. As polymerization occurs in the presence of the desulphurization catalyst, rerunning, which is unnecessary for straight run, is required when cracked gasolines are treated. Although catalytic desulphurization can be operated on straight-run gasolines with a loss of only ½ to 1 per cent, a polymerization loss of several per cent will occur when processing cracked gasolines. In studying laboratory results from desulphurization work on cracked gasolines, it should be remembered that the product has usually been rerun to produce a slightly lower boiling range, which may result in what appears to be a slight improvement in octane gain over mercaptan extraction. Comparative studies should be based on products of the same boiling range.

☆ ☆ ☆ ☆

All of the known half million organic chemicals can be synthesized from either petroleum, natural gas, coal, or farm products—the raw material used depending, in each instance, on the cost of production.

At times, this process has been used on blends of straight-run and cracked gasolines. When this is done, the desulphurization of the straight-run portion of the blend is depressed and the overall results are poor, as compared to separate mercaptan extraction of the cracked gasoline and catalytic desulphurization of the straight-run gasoline.

Occasionally, a light straight-run gasoline is available that contains little sulphur except in the form of mercaptans. In this case, mercaptan extraction is recommended if the mercaptan content is significant, 0.02 weight per cent or higher. Quite often mercaptan extraction can be accomplished in a combination unit, utilizing the cracked gasoline treating facilities. For example, a light straight-run gasoline containing essentially all the sulphur in the form of mercaptans could be caustic washed, using caustic that is regenerated in a cracked gasoline caustic regenerator, or could be Unisol treated, using Unisol reagent that is regenerated in a regenerator common with a cracked gasoline Unisol unit.

One factor that contributes largely to the octane improvement of straight-run gasolines when catalytically desulphurized, is the rearrangement of some of the hydrocarbon molecules that takes place. We believe this to be isomerization. Numerous data are available, showing octane improvements from straight-run catalytic desulphurization, which cannot be accounted for on the basis of sulphur removal alone. Any comparable molecular rearrangement in cracked gasoline seems to be negated by the polymerization that takes place when cracked gasolines are catalytically desulphurized.

To summarize, for straight-run gasolines, if the laboratory catalytic desulphurization tests indicate sufficient octane improvement to justify the operating cost, catalytic desulphurization is recommended. In those cases where the straight run is of low end point, containing essentially all mercaptans, a mercaptan extraction process should be used. For extremely low sulphur straight runs, little octane improvement is possible and

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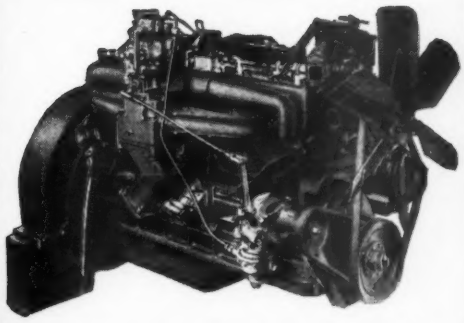

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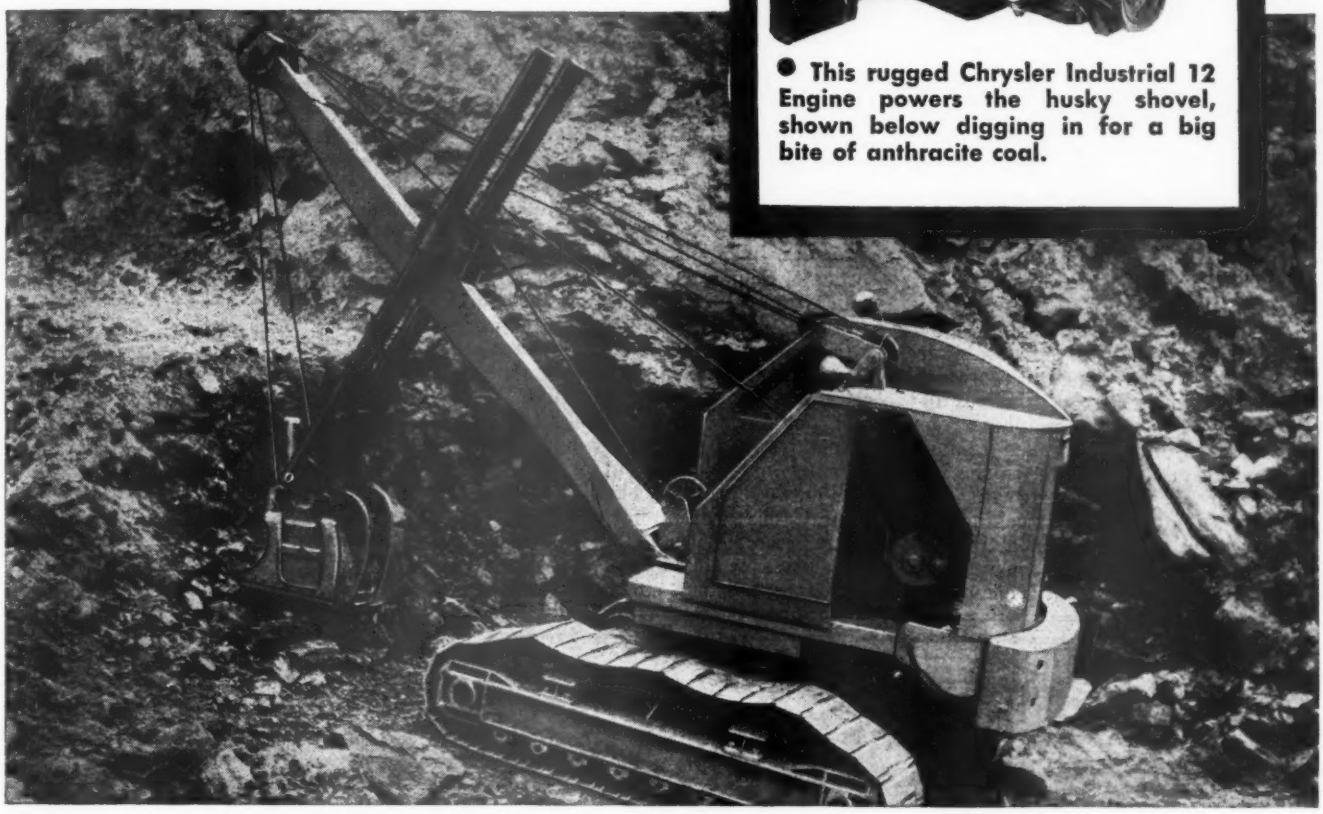

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usually a simple caustic washing unit or sweetening unit is recommended, depending upon whether or not a strict interpretation of the doctor test is required.

The case for sulphur removal units of the foregoing mentioned types can be made very strong indeed. Frequently, severe reforming of the straight-run gasoline can be avoided by catalytic desulphurization. These processes, particularly high temperature clay desulphurization and Unisol treating, are not appreciably affected by the sulphur content of the charging stock. In other words, a switch can be made from extremely low sulphur to high sulphur crude without changing the treating equipment. The West Texas crudes, for example, are so high in sulphur that many of the older processes, such as doctor sweetening and copper sweetening, fail miserably in processing them.

Some of you may already be aware of the Isoforming process, which is used to improve the octane number of thermally cracked gasolines or of blends of thermally cracked and straight-run gasoline. This process is carried out in a similar manner to catalytic desulphurization, and was developed to overcome, to a large degree, the two principal disadvantages of catalytic desulphurization of cracked gasoline, or cracked gasoline in blends with straight run. In the Isoforming process these disadvantages, polymerization and catalyst coking, are minimized by employing an active catalyst at extremely high space velocity, so that the desired reaction is completed and the material removed from contact with the catalyst before the polymerization and catalyst coking reactions can take place to any great extent. Of greater importance than the actual octane number improvement that Isoforming gives, is an improvement in the blending octane number. Actual clear octane number improvement may be as high as 3 to 6 points, depending on the octane number and bromine number of the charge while blending octane number improvement may be as much as 10 points; depending, of course, upon the properties of the other components of the blend. Isoforming effects some desulphurization, though perhaps not as much as catalytic desulphurization, and this, no doubt contributes to the improvement in octane number; however, it is felt that the principal advantage is in the isomerization that takes place.

Optimum results in Isoforming are obtained at the lowest practical operating pressure, but high temperatures, in the order of 950 F, are used. As some carbon is formed on the catalyst, about 0.1 to 0.2 per cent by weight of the charge, regeneration is required. Catalyst regeneration is not difficult as the amount of catalyst in the plant is small. A 1000 bbl. per day plant uses about 1400 lb. of catalyst in two vessels, which are alternately on process and regeneration, and only 10-20 lb. of coke is burned per hour. Catalytic desulphurization units by comparison require 10,000 to 20,000 lb. of catalyst for 1000 bbl. per day. Process loss—gas, polymer, and catalyst deposit amounts, on Isoforming, to 2 to 4 per cent.

This process is competitive with Unisol treating on some cracked gasolines, having an appreciable mercaptan content, for although it costs considerably more to install, there is often more to be gained. Unisol will not show much improvement on low mercaptan gasolines, whereas Isoforming may show its greatest improvement on this type of stock. On the other hand, Unisol treating of some high mercaptan gasolines may give leaded octane improvements nearly as great as Isoforming will give.

Strictly speaking, Isoforming is not considered a desulphurization process, but is mentioned in this article because it is competitive with treating processes, and from a standpoint of its functional place in refinery operaions and the capital investment involved, it can be placed in this general category.

It is hoped that the foregoing will be an incentive to further study of these problems and will offer a laboratory approach to aid in solving them.

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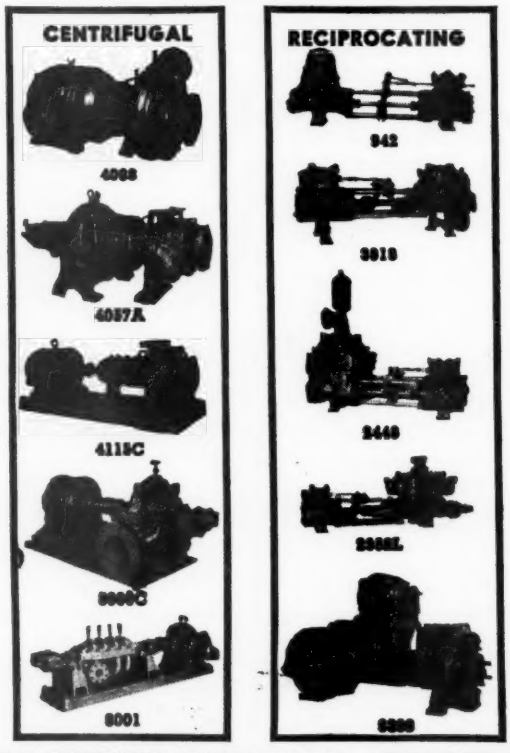

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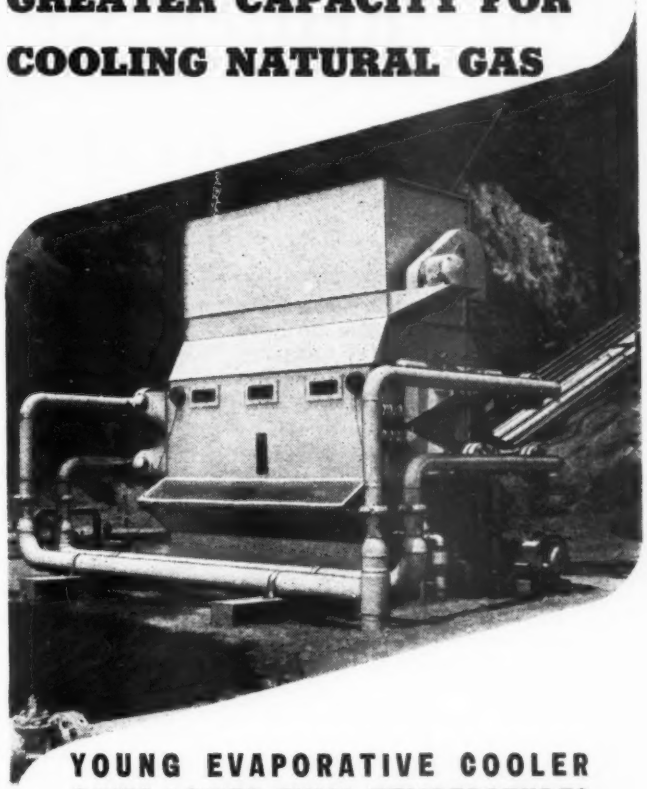

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Wells drilled with horizontal drain holes

IN THE Round Mountain field, Kern County, California, 15 miles northeast of Bakersfield, the Shell Oil Company, Inc., has completed an interesting test of the Zublin method of drilling horizontal drain holes.

This particular well was chosen for the following reason: The main oil sand is in an 80-ft. zone near the bottom of the well, and it had 8⅝-in. casing, which is ideal for this test. No core analysis, however, was available on this well, but the average permeability of the sands in this zone is about 100 md.

The well had been drilled to a total depth of 1720 ft, and 16-in. surface casing had been set and cemented at a depth of 30 ft. The elevation of the derrick floor was 1055 ft.

The well was cased with 8⅝-in., 32-lb and 36-lb lapweld pipe cemented at 1381 ft. A 6⅝-in., 26-lb lapweld liner was hung from 1354 ft to 1718 ft. A perforated 100-mesh screen was used from 1379 to 1718 ft.

● **Horizontal drilling equipment.** The bits used for drilling horizontal drainage holes in this test were of the rotary turbine type with a 6-in. diam. cutter. Power to rotate the turbine was derived from fluid pumped down the drill string to the bit. The Zublin operators recommended a flow of approximately 7 bbl per min in this test. This rate of flow was maintained in most of the holes drilled in this well with an average pump pressure of about 600 psi.

The turbine bit assembly consisted of three main parts: (1) The housing that carried the nozzles of the turbine, (2) the shank member with the turbine runner mounted on ball bearings within the housing, and (3) the cutter element that is mounted on ball bearings. The cutter element is free to rotate about an axis that is inclined with respect to the axis of rotation of the shank.

The cutting action of the bit is credited to the tendency of the bit to cut opposing teeth in the formation facing the teeth of the cutter. If the bit were hanging free, the cutter would rotate at about the same speed as the turbine, or about 4000 rpm. As the cutter face is forced against the formation, however, these "rock" teeth retard the rotation of the cutter by the ratio of one to ten, i.e., 400 rpm for the cutter about its inclined axis as compared to 4000 rpm of the turbine and shank.

The cutter, however, wobbles at the rate of 4000 times per minute due to the inclination of the cutter axis. The one to ten reduction is credited to the placement of the cutter teeth, which were designed to remove one-ninth of the opposing "teeth" in the formation on each revolution of the turbine or the corresponding wobble of the cutter face. The cutting action of the bit depends in part upon the tendency of the cutter teeth to lift and drop the bit.

The entire bit has an overall length of 20 in. to permit the drilling of curved holes. The fluid is discharged close to the cutter teeth. The construction of the bit provides for ready disassembly and reassembly to permit replacement of parts of the turbine that are worn by cutting or the abrasive action of the drilling fluid.

● **Flexible drill pipe used.** The flexible drill pipe is made from 4½-in. external

FIG. 1. Sketch of tool string used in drilling horizontal hole.

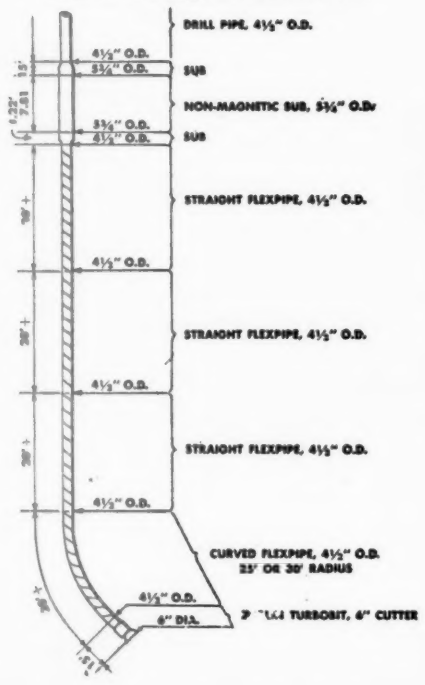
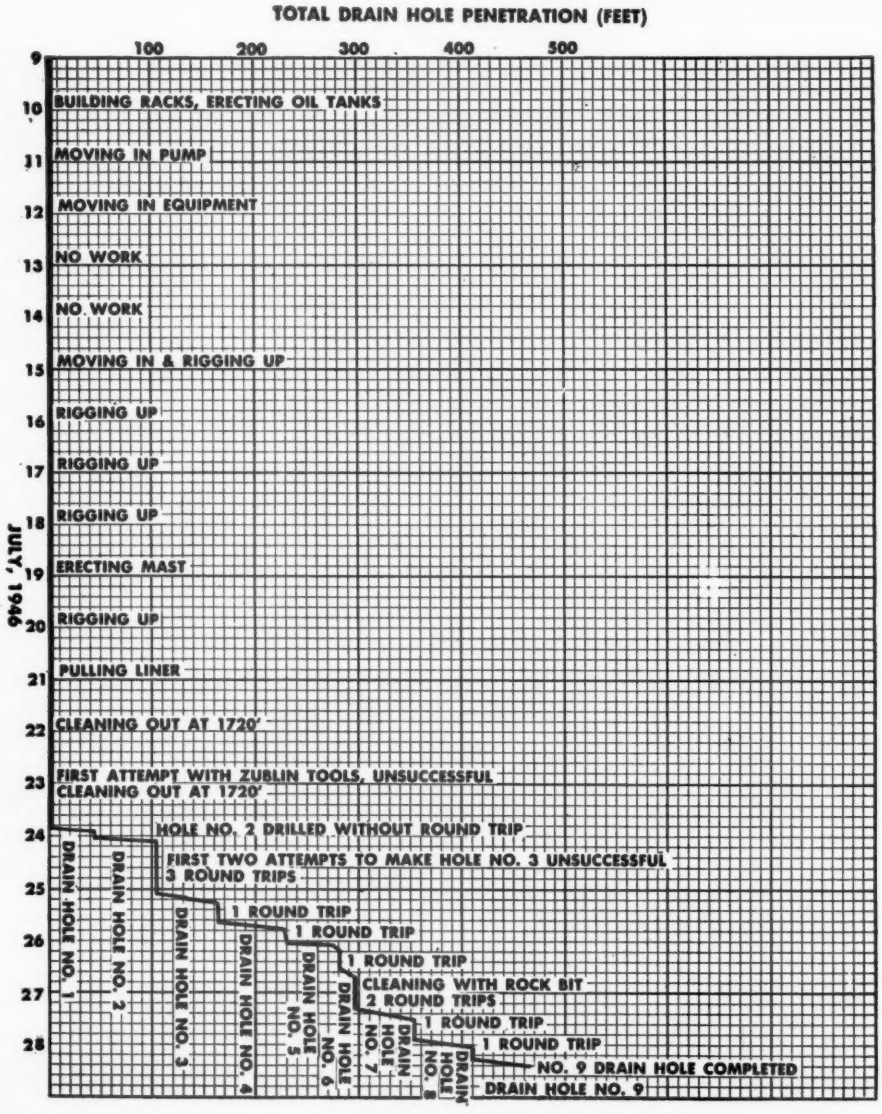
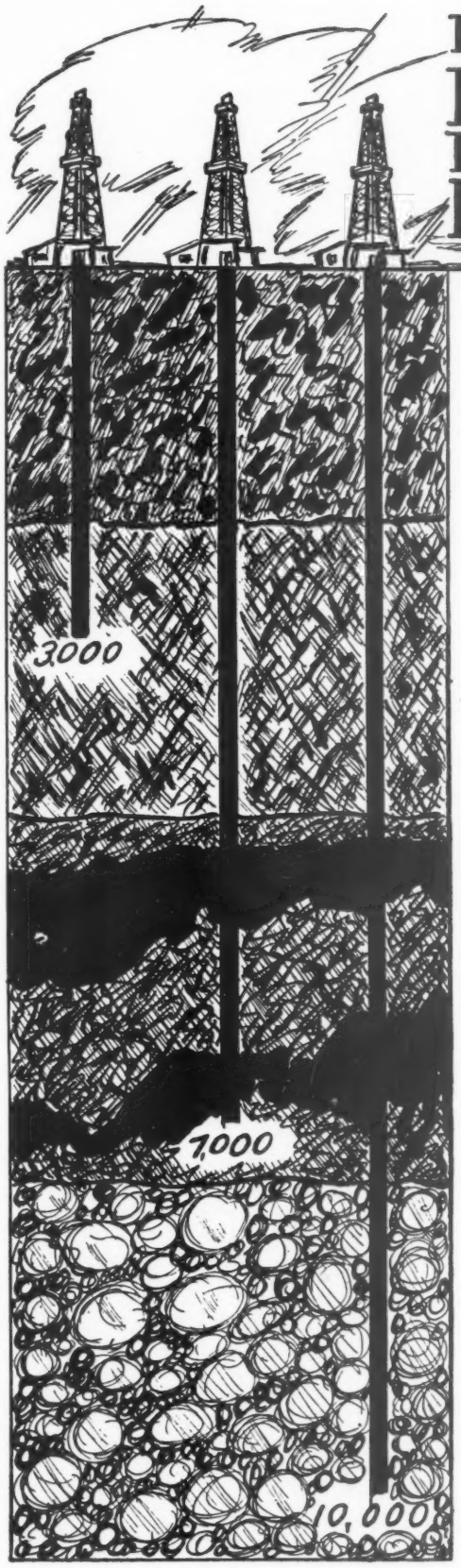


FIG. 2. Progress curve—horizontal drilling.





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Elements required to drill oil well horizontally—a straight mandrel to insert in curved flexible drill pipe, and turbine bit connected at end of curved pipe actuated by high pressure drilling.

flush joint drill pipe. A continuous spiral slot is cut through the wall of each joint of pipe except for a distance of 15 in. at each end. The joint is lined with a high-pressure synthetic rubber hose that is made fluid-tight at each end to prevent leakage of the circulating fluid. The spiral cutting of the straight flexible pipe provides the flexibility required for the string to change from a vertical hole into a curved hole and then into a horizontal hole.

A curved flexible joint is used directly above the turbobit at the lower end of the string. This pipe is similar in construction to the straight flexible pipe except that it has been heat-treated to maintain its curved form. The radii of curvature range from 20 to 35 ft. The curved joints used at this well were all 25 ft in radius except for one joint used in drilling two drain holes. This joint had a radius of 30 ft. It is claimed for the 25-ft radius joint that the force of gravity will allow the bit to continue in an approximately horizontal direction once it has reached this position.

A mandrel is inserted as a core through the curved section of pipe before it is run into the well. The curved joint is straightened out and held in this position by a clamping device before the mandrel is inserted. The mandrel is equipped with a spear at the top for the purpose of withdrawing it from the curved section of pipe. After the flexible pipe has reached its point of operation, the mandrel is withdrawn by means of retrieving tools run on a sand line. The curved pipe then assumes a curved form within the limits of the hole at this point, forcing the bit against the sidewall.

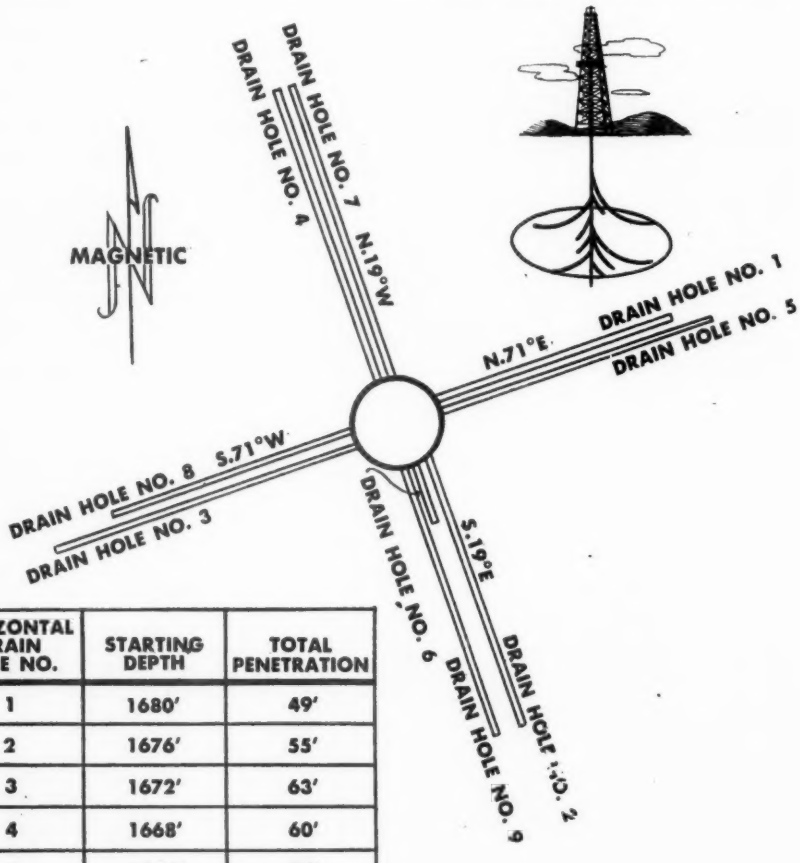
● **Magnetic compass and non-magnetic sub.** A Zublin magnetic compass was used in the horizontal drilling operation. With the exception of a steel swivel at the upper end and a steel bull-nose at the lower end, the housing is made of brass. It is 6 ft 6 in. long and 2 3/16 in. OD. The timing mechanism to lock the compass needle is housed in the lower half of this unit. It operates thus:

A compressed spring exerts pressure on a leather packer within the tube; the movement of the packer, which in turn is connected to a long pin, is retarded and controlled by the flow of oil through a small orifice; about 12 min after the release of the mechanism, the pin compresses a small cylinder beneath the compass needle locking it in the position it points at that moment. The needle will remain locked in this position until released at the surface. The upper section of the housing has a stainless steel, hinged lug designed to orient the compass assembly in the same positions with respect to the non-magnetic sub every time the compass is run into the sub on a sand line.

The sub is constructed of non-magnetic stainless steel and is 7 ft 10 in. long and 5¾ in. OD. This sub has an internal slot to provide positive orientation of the compass assembly with respect to itself.

● **Pre-drilling procedure.** Fig. 1 illustrates the typical string of Zublin tools suspended on conventional 4½-in. OD drill pipe as used in the drilling of drain holes in Freeman 11. With the mandrel inserted in the curved joint of flexpipe this string is run in until the bit has reached the depth at which the horizontal hole is to take off from the vertical. The mandrel is removed and the flexpipe allowed to return to its curved form to the extent the hole will permit.

All joints of Zublin flexpipe and subs, from the curved joint up to and including the non-magnetic sub, have vertical alignment marks chiselled at the ends of each joint. These marks, with the aid of a protractor, provide the means for determining the relative angles of adjacent joints. The algebraic sum of angles to the right and left provides the bearing of the non-magnetic sub with respect to the curved flexpipe and bit. The magnetic compass is run in on the sand line until it is positioned in the non-magnetic sub. After an interval of approximately 15 min the compass assembly is thus withdrawn from the string and the compass bearing of the non-magnetic sub is thus determined. With this information, knowing the relative bearing of the non-magnetic sub and the curved flexpipe, the present compass bearing of the curved flexpipe and bit is thus deter-



HORIZONTAL DRAIN HOLE NO.	STARTING DEPTH	TOTAL PENETRATION
1	1680′	49′
2	1676′	55′
3	1672′	63′
4	1668′	60′
5	1664′	54′
6	1660′	13′
7	1660′	60′
8	1656′	49′
9	1650′	55′

FIG. 3. Diagrammatic sketch showing scheduled orientation of horizontal drain holes.

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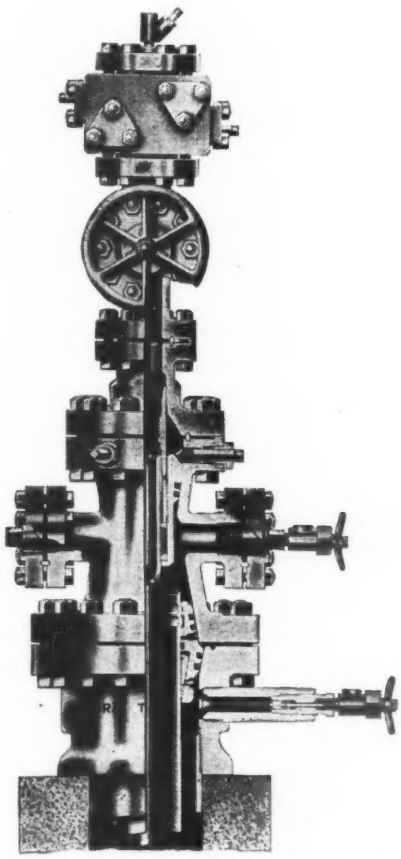

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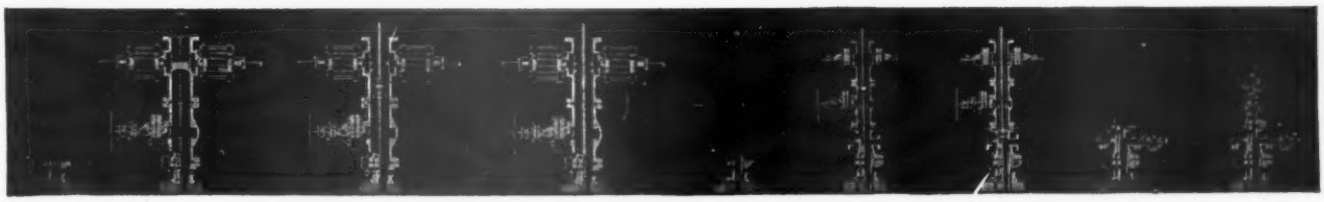
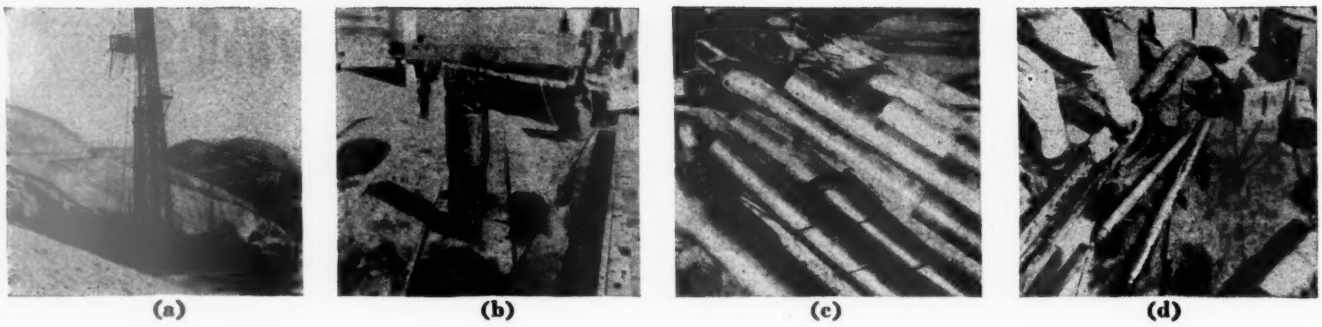


Casing Head Attached | **Drilling** | **Running Casing** | **Casing Landed** | **Drilling Control Equipment Removed** | **Drilling-in and Running Tubing** | **Tubing Landed** | **Control Equipment Removed** | **Manifold Attached**



(a) (b) (c) (d)

(a) Shell, Freeman-11 viewed from oil tanks on hill north of well.

(b) Zublin Turbobit—6 in. cutter. This bit had been used in drilling drain holes No. 1 and No. 2.

(c) Ruptured Flexpipe resulting from application of excessive weight on bit during drilling of hole No. 3. In this case it is estimated that up to six points of weight were applied on the bit. The weight indicator was not functioning at the time this weight was applied.

(d) Zublin bit orientation equipment, showing protractors, compass housing, and magnetic compass.

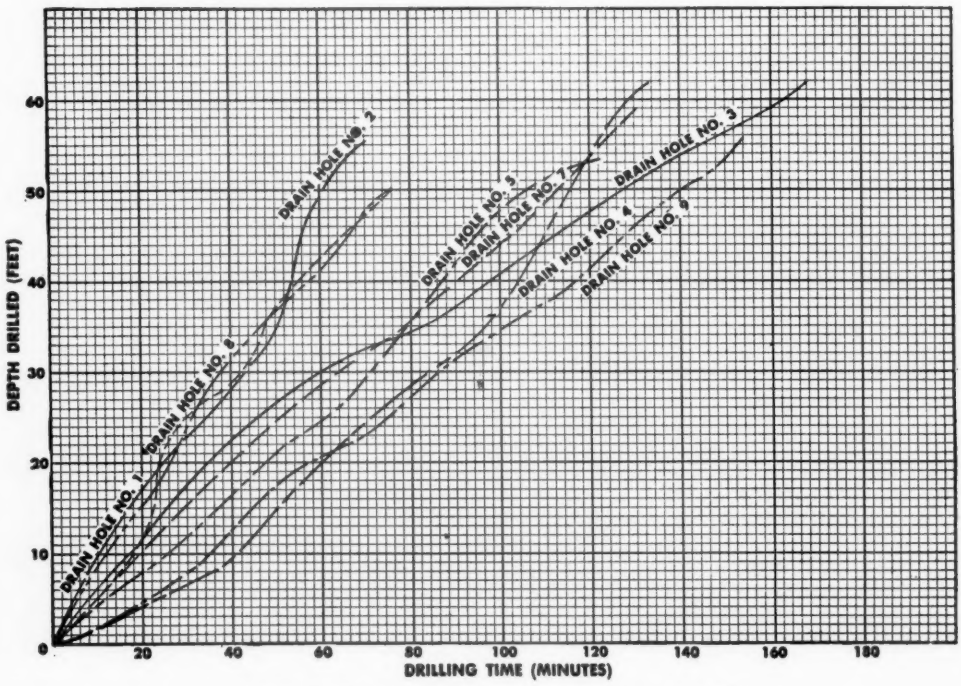


FIG. 4. Depth vs. time curves—horizontal drilling.

mined. The string of pipe is then rotated at the surface to the desired azimuth.

As soon as the pump is started, the bit rotates and begins digging a new hole in the wall of the vertical hole.

Horizontal drain holes No. 1 through No. 4 were oriented in the manner described above. The remaining holes were surveyed, the string of pipe was rotated, and the mandrel pulled after the bit had been oriented to the direction in which respective holes were scheduled to penetrate formation. This method insured the free rotation of the entire string of pipe during the orientation of the bit. Inasmuch as the mandrel can be inserted in the curved flexpipe at the surface only, the latter procedure necessitated a round trip for each drain hole.

After all lateral holes were drilled, the same size liner was placed in the well as was originally in the hole and the well placed on the pump.

● **Drilling fluid.** Anticipating a considerable loss of fluid to the formation, 4500-bbl oil storage capacity was provided for this operation. It was found, however, that approximately 450 bbl of oil were lost into the formation while removing the liner and 650 bbl of oil were lost into the formation while drilling the 458 ft of drain holes. Thus the actual loss of fluid while drilling the drain holes amounted to 1.4 bbl per ft. The rubber lining of the flexpipe has a bursting pressure of 100 psi, in the flexpipe just above the turbine bit.

There is no apparent relationship existing between the drilling rate and the circulating volume. The discrepancies in the pump pressures and circulating rates as shown on the accompanying charts are probably caused by gas locking in the pump, for the actual pump displacement was not measured but merely calculated from the pump speed.

● **Conclusion.** Sufficient evidence of cuttings in the ditch and weight on the bit was observed to indicate that nine drainage holes had actually been drilled.

The turbobit performed satisfactorily on all drain holes. Frequent bit changes were made but this was done to insure trouble-free drilling inasmuch as round-trips were necessitated in any case by the adopted method of orientation. At no time could failure to penetrate formation be attributed to the performance of the bit. A total of four bits were used in drilling the 458 ft of hole, although considerably more footage could have been drilled with the bits since they were not very dull.

The flexpipe performed satisfactorily in most of the drain holes drilled. In the few cases where the pipe actually ruptured, halting further drilling progress, the failures were attributed to excess weight on the bit. Zublin representatives recommend approximately 1000 lb as the ideal weight on the bit for drilling with their equipment.

Although the drainage holes were stopped after penetrating 50 to 60 ft into the formation, it is believed that the holes could have been drilled much farther (80 to 100 ft) without any mechanical difficulties.

● **Comments by inventor of horizontal drilling method.** In commenting upon the test made in the Shell well described herein, John A. Zublin stated that a significant improvement was introduced in the test in the use of oil instead of water or water-base mud as the motivating fluid for the turbine. This new technique, he states, has eliminated the danger of impairing production by water flooding or "mudding" of the oil sand and has the added advantage of providing a helpful lubricating action.

He further stated: "Results of this latest drain hole project have again confirmed our belief that one of the benefits of large drainage channels is to greatly reduce sand troubles. The rate at which

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oil flows through the large drain holes is so much less than in the case of ordinary wells, where only minute passages or cracks are available, that less sand will be dislodged and in any event will settle out before reaching the main bore of the well. This will result in considerable savings in liners, pumps, and other production equipment, as well as reduce the danger of wells sanding-up.

"Thus far, drilling of horizontal drain holes has been confined to 'old' or partially depleted wells, and all projects have been approached as methods of secondary recovery. It may well be, however, that far greater benefits will be derived from drilling in 'new' wells. This would mean drilling horizontal holes into the oil sand immediately upon completion of the vertical bore and prior to placing the well on production. With a greatly increased drainage area, and unimpeded passages for the oil to travel from all directions to the central hole, the new well could be produced at a much higher rate without exceeding the limits of efficient production or encouraging sand problems, or other problems. Production of a well is in a sense an underground transportation problem involving the movement of oil and gas from distant points in the formation to the well with the least amount of turbulence and resistance to flow. In conventional wells the oil and gas must force its way horizontally at high velocities, through small openings and pores in the sand to a point in the well from where it will be lifted vertically and it is to be expected that in this 'race' the more viscous gas will tend to bypass the oil. The slow and uniform drainage created by lateral holes will preserve the gas pressure in the formation and maintain a more constant and controlled gas-oil ratio. These factors will undoubtedly bring about a greater ultimate recovery of oil, as well as a more rapid and consequently more efficient and economical recovery. This same contention applies to decreased water production, for, similarly, the tendency for the water to bypass the more viscous oil is less at a slower rate of production. This point has been definitely brought out in the tests thus far completed, for in all wells the percentage of water produced declined after completion of the drainholes.

"Considerable thought has been given to the problem of reducing costs of drilling lateral holes. Since, in the process employed, the pipe remains stationary and only the bit rotates, no torque is set up, making it possible to use smaller pipe, which can be handled with light, portable equipment. In this respect, conditions are similar to well-servicing operations.

"Costs can also be reduced by adopting a program calling for the drilling of drain holes in a number of wells. It then becomes profitable to use the best suitable equipment to complete all the jobs. In 'new' wells, drain holes can be provided at a fraction of the cost involved in 'old' wells, for no special rigging-up is required and the holes can be drilled within one or two days after completion of the main bore." ★ ★ ★

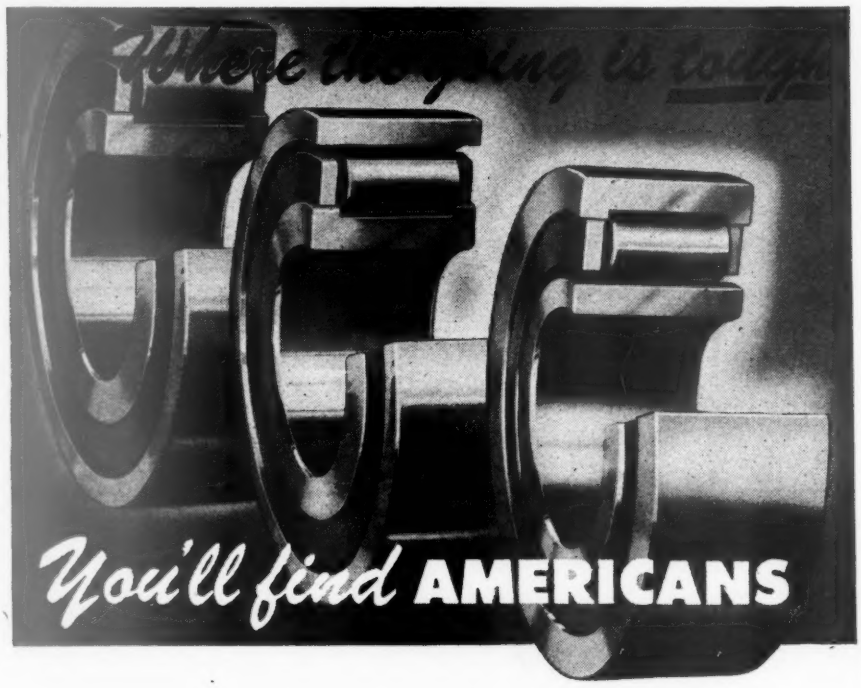
A.A.P.G. convention

The American Association of Petroleum Geoloists will hold its 32nd annual meeting at the Biltmore Hotel in Los Angeles, March 24-27. The annual meeting, last held in Los Angeles in 1937, will be a joint conference with two affiliated societies of the association; the Society of Economic Paleontologists and Mineralogists and the Society of Exploration Geophysicists.

The technical program for the three-day session is designed to present and explore problems encountered by petroleum geologists working in lands adjacent to the Pacific Ocean. Following this session there will be a three-day field tour of California oil field districts.

Earl B. Noble, manager of exploration of Union Oil Company and national president of the AAPG, has announced that plans are in the final stages for an interesting and informative geological meeting.

The Pacific Section of the AAPG will act as hosts to the visiting geologists. Committee chairmen of this section who have carried forward the task of arranging the meeting are: General convention chairman, Harold W. Hoots, consulting geologist; technical program, R. W. Clark, Western Gulf Oil Company; finance, John McMillan, Fullerton Oil Company; entertainment, E. R. Atwill, Union Oil Company; reception, C. R. McCollom, consulting geologist; exhibits, W. P. Winham, Standard Oil Company; hotels and housing, V. W. Vandiver, Seaboard Oil Corporation; registration, Vernon L. King, consulting geologist; field trips, John C. Hazzard, Union Oil Company; transportation, H. J. Steiny, Tide Water Associated Oil Company. Ladies entertainment will be under the direction of Mrs. Carroll M. Wagner.



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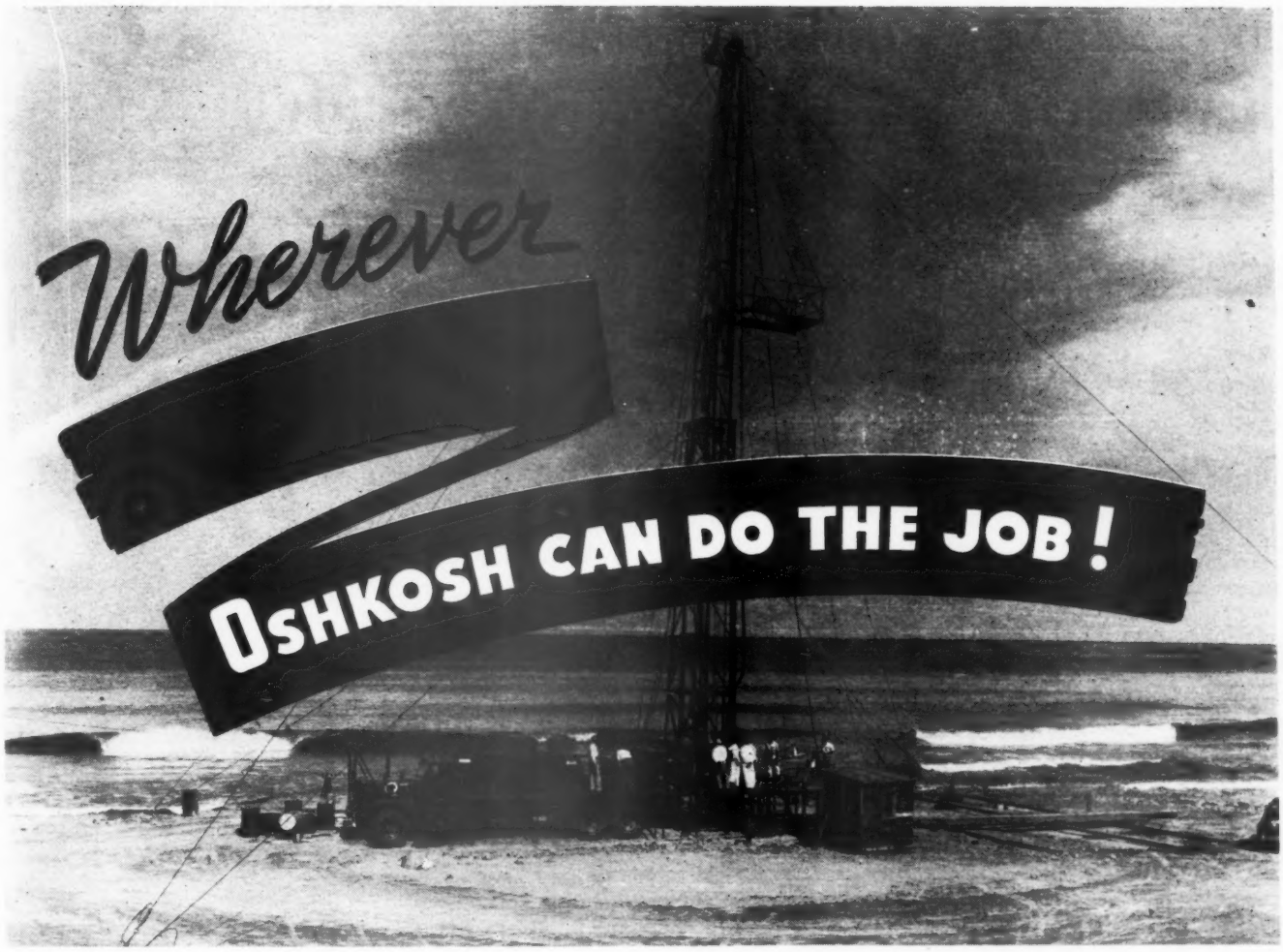

In foreign fields, as well as in North America, Oshkosh 4- and 6-Wheel-Drive Trucks perform well the multi-purpose jobs of the Oil Industry, transporting drilling and servicing equipment to the field and providing the power for its operation. The photograph above of a 6-Wheel-Drive Oshkosh Truck providing the power for transporting the equipment and drilling the well was taken at **Talara, Peru, on the shore of the Pacific ocean.**

Manufacturers of portable Oil Field Equipment praise Oshkosh Trucks. They have found the heavy Oshkosh Frames are so constructed that is has been found unnecessary to add frame reinforcement to handle even the heaviest drilling and servicing equipment. The Oshkosh Truck is engineered and designed to take all auxiliary equipment with a minimum of change. If you are faced with the problem of transportation and operation of such equipment, specify Oshkosh Trucks.

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Left, a Franks Rotary Drilling Unit mounted on an Oshkosh Model W-1600-BDH All-Wheel-Drive Truck, and capable of drilling 4,000 to 8,000 feet.

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Chart for making dilution calculations

By **W. C. FRISHE,** *Professor of Chemical Engineering and Metallurgy,*
Grove City College, Pennsylvania

A TYPE of problem common in pilot plant practice and recurrent also in large scale work is the problem of dilution. In blending, dilution of solutions and purging of tanks a differential equation must be set up either (1) for calculating the necessary rate of diluting stream that will accomplish the desired concentration change in a definite time, or (2) for calculating the duration of the operation at a given rate of diluting stream that will accomplish the desired concentration change, or (3) for determining necessary initial and final concentrations for a given rate of diluting stream and a given duration time of operation. In any case, it is necessary to assume instantaneous mixing, unless special data are at hand, and it is necessary to set up and solve a separate differential equation in each case.

EXCLUSIVE

The accompanying nomograph based on (1) constant volume for a given operation, (2) constant rate of flow of diluting stream, and (3) instantaneous mixing allows easy and quick determination of any of the five variables (duration time of operation, rate of flow of diluting stream, volume of system, initial concentration, and final concentration) when the other four are given.

The equation on which the nomograph is based was developed in the following way.

Let C = solute concentration (based on volume) at time, t.
V = total volume of tank
R = solvent rate (volume/time)

Then, by a solute balance:

$$-VdC = RCdt$$

$$\int_{C_1}^{C_2} \frac{dC}{C} = \frac{R}{V}\int_0^t dt$$

$$\ln \frac{C_1}{C_2} = \frac{Rt}{V}$$

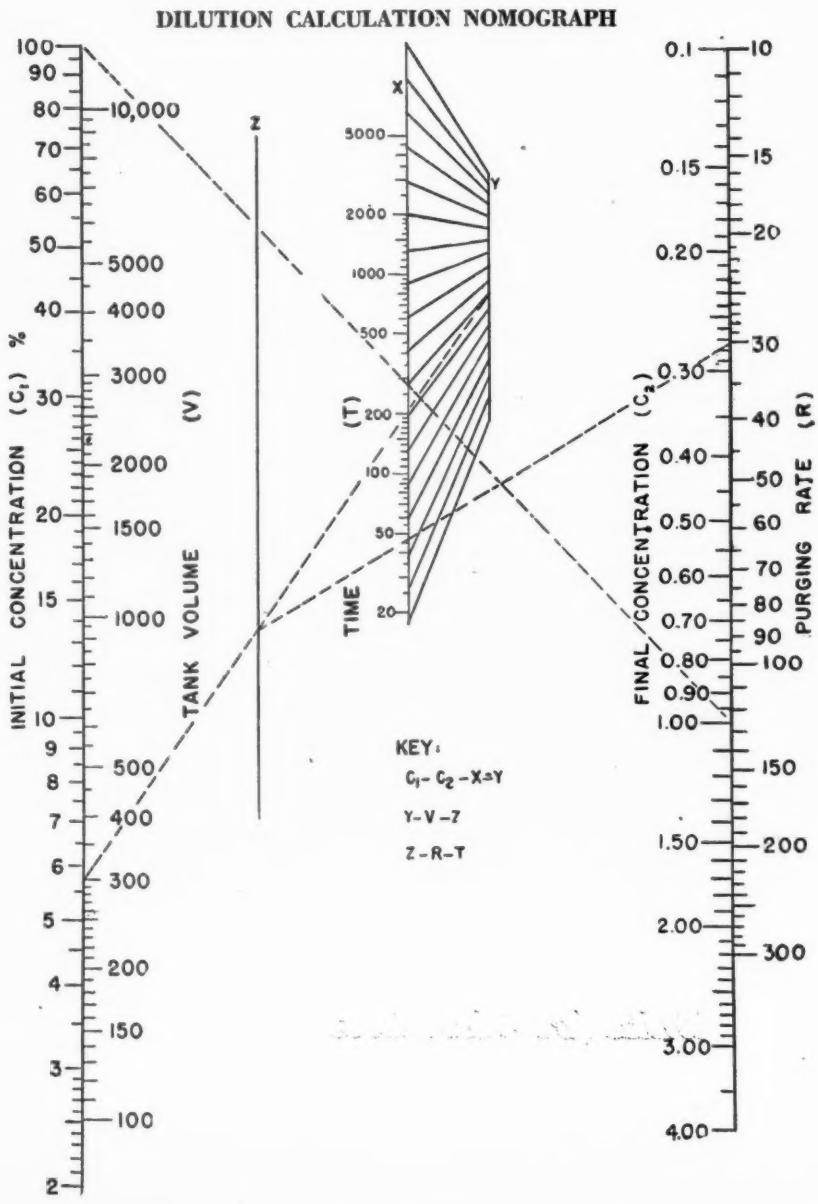
$$t = 2.303 \frac{V}{R} \log \frac{C_1}{C_2}$$

From this it is seen that C_1 and C_2 (initial and final concentrations) have the same units. R has the same volume unit as V and the same time unit as t.

The following examples will help to make the general method of using the nomograph clear.

Example 1: A 1000 cu. ft. tank containing 75 mol per cent hydrogen and 25 mol per cent carbon dioxide is to have the hydrogen content reduced to 1 mol per cent by bleeding in nitrogen at a constant rate. When the hydrogen content is down to 1 per cent the tank may be opened to the air and welding operations may proceed. How long will it take to do this? On the nomograph connect 75 on the C_1 scale with 1 on the C_2 scale. From the point of intersection on the X line follow the guide lines to the corresponding point on the Y line. Connect this point and 1000 on the V scale. Using the point of intersection on the Z line as a pivot one can readily estimate the flow rate necessary to complete this operation in a reasonable time. At a flow rate of 30 cu. ft. per min. the operation will require 140 min.

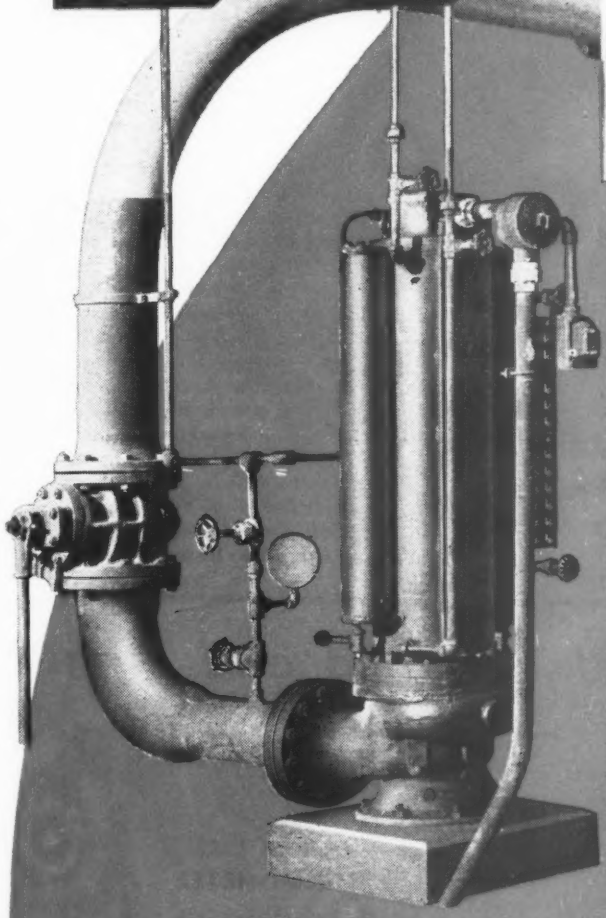
Example 2: A 300 cu. ft. tank containing propane at atmospheric pressure is to be purged with nitrogen at the rate of 30 cu. ft. per min., until the propane content is not more than 1 per cent by volume How long will it take to do this? As shown by the lines already in place on the nomograph the time required is 46 min.



BJ Stuffingboxless Pumps

NO PACKING
because there is no stuffingbox

NO LEAKAGE
of pumped liquid to atmosphere
because of the seal oil system



BJ Process Type Stuffingboxless Pump, installed at Union Oil Company's Wilmington Refinery. Size: 4 x 6 x 10LL. Pumps Iso-Butane at 130° F.; 450 gpm against a 450 foot head. Several hundred BJ Stuffingboxless Pumps are in service.

For pumping costly, volatile liquids, BJ Stuffingboxless Pumps are unequalled. With these pumps, leakage to atmosphere is *impossible;* hence they are ideally adapted to pumping butane, propane, ethane and other extremely volatile hydrocarbons.

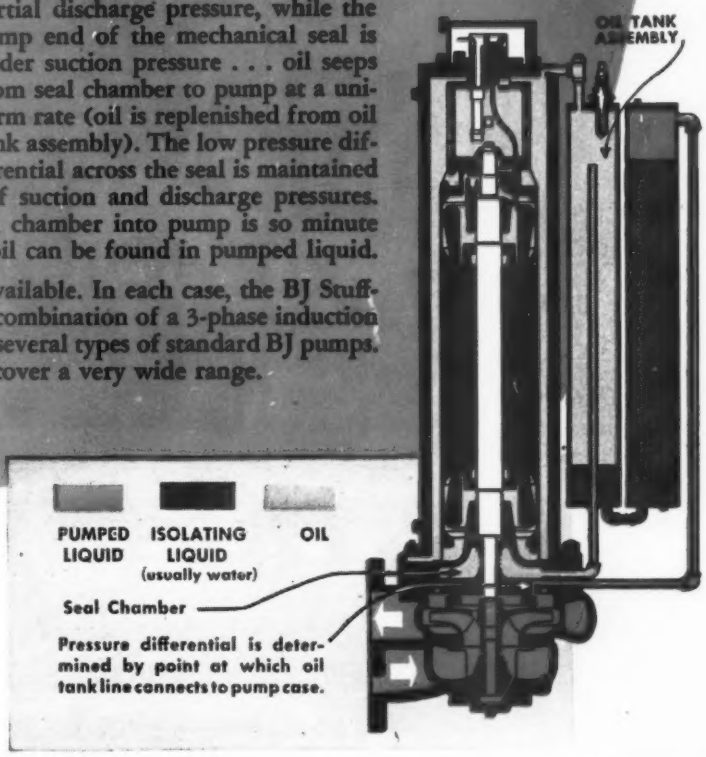
Sealed Motor is direct-connected to the pump. Motor is housed in a steel case filled with an oil of high dielectric strength. The oil provides both electrical protection and lubrication.

Mechanical Seal. A double mechanical seal, contained in an oil-filled seal chamber, replaces the stuffingbox.

Oil Tank Assembly. A two-compartment oil tank assembly holds the auxiliary motor oil supply and provides a method by which partial discharge pressure is transmitted to motor oil and seal chamber.

Fixed Pressure Differential Across Seal. Since the motor and seal chamber is under partial discharge pressure, while the pump end of the mechanical seal is under suction pressure . . . oil seeps from seal chamber to pump at a uniform rate (oil is replenished from oil tank assembly). The low pressure differential across the seal is maintained *constant,* regardless of suction and discharge pressures. Oil seepage from seal chamber into pump is so minute that no trace of seal oil can be found in pumped liquid.

Several Types are available. In each case, the BJ Stuffingboxless Pump is a combination of a 3-phase induction motor and any one of several types of standard BJ pumps. Capacities and heads cover a very wide range.


OIL TANK ASSEMBLY
PUMPED LIQUID
ISOLATING LIQUID (usually water)
OIL
Seal Chamber
Pressure differential is determined by point at which oil tank line connects to pump case.

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Example 3: A catalyst chamber having a free volume of 200 cu. ft. contains air at atmospheric pressure. The oxygen content must be lowered to 0.1 per cent before a hydrogen stream can be introduced for the reduction of the catalyst. If pure nitrogen can be bled in at the rate of 10 cu. ft. per min. how long should the purging operation proceed? Connect 21 on the C_1 scale with 0.1 on the C_2 scale. From the point of intersection on the X line follow the guide lines to the corresponding point on the Y line. Connect this point and 200 on the V scale. Connect the intersection point on the Z line with 10 on the R scale and read the answer (107 min.) on the T scale.

Very slow flow rates (less than R=10) can be handled if it is seen that V and R occur in ratio. If, for example, it is desired to use a flow rate of 5 cu. ft. per min. into a 300 cu. ft. tank this is the same as 50 cu. ft. per min. into a 3000 cu. ft. tank.

Example 4: Reduce 100 per cent propane to 1 per cent in a 300 cu. ft. tank by introducing nitrogen at the constant rate of 5 cu. ft. per min. How long will it take? R = 5 cannot be read on this nomograph so make calculation for V = 3000 and R = 50. Answer 275 min.

Obviously, in any actual purging operation there will be a certain amount of displacement because mixing is not perfect. This will result in a shorter time being required than is calculated. The time estimated from the nomograph will, therefore, be the maximum time required. If it is desired to dilute a gas accurately to a certain concentration in the manner outlined above precautions should be taken to have the mixing as nearly complete as possible. This means that the rate of flow of the diluting stream should be small in comparison with the tank volume and that mixing devices should be used. If care is taken to have thorough mixing the nomograph may be used on problems of the type of example 4.

Example 4: A tank contains 500 gal. of salt solution that is 19 per cent salt by weight. Water is to flow into the tank at the rate of 10 gal. per min. and the solution will overflow at the same rate so that the tank always contains 500 gal. of solution. This operation is to be carried on until there remains in the tank 500 gal. of solution that is 0.8 per cent salt by weight. How long will it take? Connect 19 on the C_1 scale with 0.8 on the C_2 scale. From the point of intersection on the X line follow the guide lines to the corresponding point on the Y line. Connect this point and 500 on the V scale. Connect the point of intersection on the Z scale and 10 on the R scale and read the answer (158 min.) on the T scale.

★★★

★★★★★★

The diesel engine was patented by Rudolf Diesel in 1892. Its greatest growth was from 1939 to 1945, when estimated dollar production grew from $45 million to more than $1 billion.

C.N.G.A. meeting

At the January meeting of the California Natural Gasoline Association, at the Rio Hondo Golf Club in Downey, California, two papers of more than usual interest were presented. One of these, an exposition of the delayed coking process by Randal Maass and R. E. Lauterbach of General Petroleum Corporation, is being reprinted in its entirety in *The Petroleum Engineer*.

The second paper, on which Barclay Thompson and Henry Curtis of The Fluor Corporation, Ltd., collaborated, was presented by the former, and described the development of a new electronic indicator. It was pointed out that during an investigation of the effects of pulsation dampeners on compressor efficiency, it was found that mechanical type indicators have two disadvantages in high speed, high pressure work, viz, erroneous indication of cylinder operating conditions because of the inertia of the indicator parts and the effects of resonance; excessive time required for installing and removing the equipment.

Realizing the need for an instrument without these limitations, Fluor engineers designed and built an electronic indicator. This can be installed quickly; is capable of following piston movements without inertia effects; and can follow pressure changes varying in frequency from zero to 30,000 cycles a minute. The cards are produced on the screen of a cathode ray oscilloscope on which calibration lines have been imposed. The vertical deflection of the beam is proportional to the cylinder pressure, while the horizontal deflection is proportional to the position of the piston. For permanent record, the card may be photographed.

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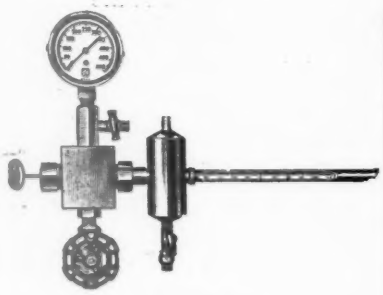

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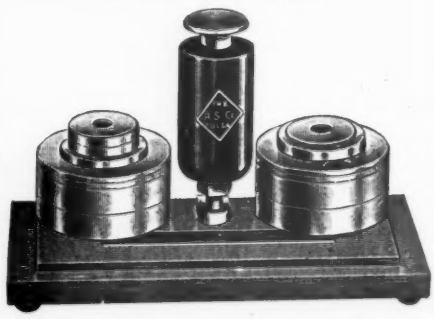

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There is a job to be done

By **REESE H. TAYLOR,** *President,* Union Oil Company of California

MR. CHAIRMAN, ladies and gentlemen. The annual award of the American Council on Public Relations is significant of the increasing importance attached to public understanding of the American way of life. While I am honored and happy at being the winner, the award is really being presented to a type of public relations rather than an individual. That is truly a high compliment.

Before I ever heard the title "Public Relations" applied to a specific job or position, it had always seemed to me that the public—people—you and I— had a right to be informed. We have, or should have, a very legitimate and active interest in government, labor unions, international affairs, education, agriculture, and industry. When we can't get the story on these activities, we think something is wrong—that someone has something to hide.

A vast amount of hard and enthusiastic work has been done to create a false impression of American industry—its contribution to our American way of life, and its worth. You have probably heard a thousand times in a thousand different ways that "Business is run by a handful of capitalists—labor is exploited—or, the rich get richer, the poor get children," and so forth.

A highly professional job is being done, and seemingly logical arguments presented. The punch line is always that American industry should be taken over and relegated to some museum for quaint, historical oddities.

You can't expect people to accept and appreciate a situation or system about which they know little or nothing. As I see it, the job before us is to inform the public as to just what makes our American industries tick. A well and accurately informed American public can be expected to act intelligently. Given the honest facts, the public will reach a logical conclusion.

Throughout the history of the nation, our free press has done a magnificent job of enlightening the public. Its importance as a safeguard of our institutions and our way of life is beyond comparison. But if as industries and businesses we are reticent, if we won't talk, how can the press properly report our activities? We have to support our free press by supplying the facts. We have to give the press the answers.

Is this system of a free, competitive economy any good? Does it do the job better than a State monopoly? What about the standard of living provided by our system? What does this nation have that others haven't—and how did we get that way? In short, just what does American industry have on the ball?

You've got to tell them.

The job of informing the people of industry's worth is the most important task confronting us today. Everyone who has wanted to has taken a poke at us—with telling effect. You know as well as I do, you can't win an argument or sell an idea by keeping silent.

In the Bill of Rights, our Constitution states that, "Congress shall make no law . . . abridging the freedom of speech or of the press." The fact that we have the freedom to talk—to tell the true story of the American way of life makes it a duty to do so. There is no law that forces us to be silent. If we don't explain the contributions our economic system has made to America's greatness, who will? If we don't convince the public that free enterprise and freedom of the individual are a part of the same theory of government, who will? If we don't refute fallacious arguments and statements, isn't that—by omission—a crime against free speech? Beyond every other consideration, it is our duty to exercise rights of freedom of speech and press.

Just because a person buys from a particular company doesn't necessarily mean that he likes that company.

If people know and like a company, they will buy that company's goods or services. I think we can all agree on that statement, but from your own personal experiences, you know it doesn't necessarily work in reverse. During the shortages, you got meat where you could and, in all probability, damned the hand that sold it to you.

Normally, though, you go to the butcher or tailor or barber or gasoline station where the people are nice to you —where you like the "people." You can read "people" in this case as "company," "corporation" or "industry."

A corporation must serve the people well—and can exist only if it does serve them well. It isn't enough just to manufacture and sell products, no matter how good. A product has to meet three prime requirements. First, it has to be available in quantity; second, it must be of high quality, and third, it must sell at a price all can afford. A lot of people don't believe that our American system does this. They believe that a State controlled industry would produce more, better and cheaper. Right there is where a corporation justifies its existence or fails.

The story our American industry has to tell is perhaps the most fascinating and certainly the most vital in history. You can look at it from statistics, from progress, from standards of living, and from comparison to other nations. You will find that no nation, or group of nations, has equalled the productivity of this country. Nowhere else in the world do so many people have so much.

Business will go all out to tell the public what a colossal, stupendous, and absolutely terrific new product has been developed. Yet, when it comes to the all important job of telling what made those products possible, what American productivity means to the nation, the majority of top management just won't act.

The American public has to be informed of industry's contributions to the general welfare. You can't expect people to act intelligently, to choose between various systems and theories, to make right decisions, when they don't have both sides of the story. You may be sure that if we give the public all the facts, they will act intelligently.

Usually the silence concerning American industry comes from top management. If industry's story is going to be told, management will have to cooperate fully in the telling. As a start, a substantial part of the conscientious public relations counsellor's time must be spent in convincing the heads of industry that public relations isn't just a new toy or gadget. It is vitally important. By its very nature, public relations has to be top management's baby.

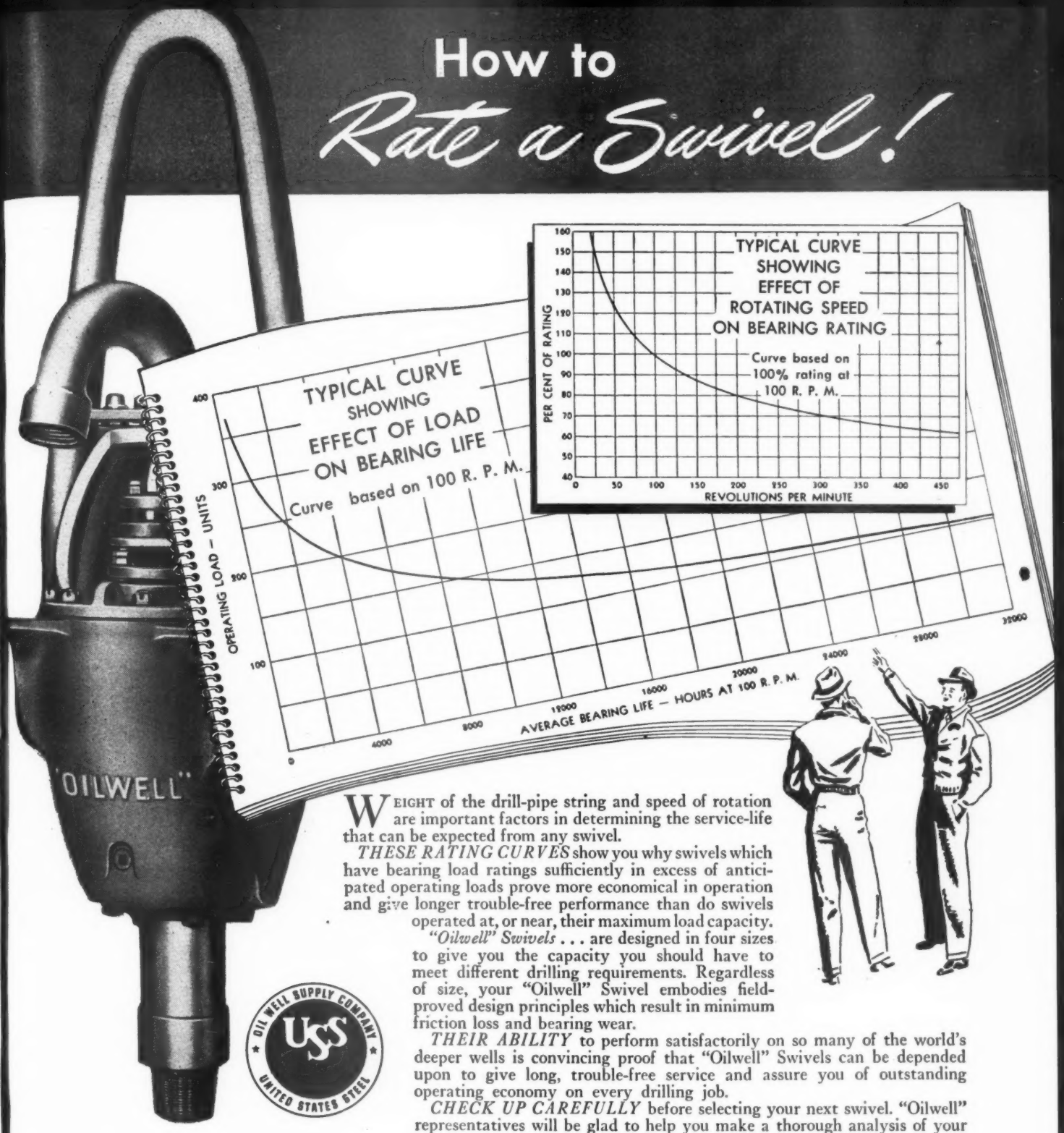
There's a world of difference between convincing the president of some company to allocate a healthy budget and actually selling him on the value of creating public good will. It isn't enough that he hire a public relations expert, give him a snappy looking office and secretary; and then completely ignore him.

A lot of able men in management think that by hiring the man and allocating the money, they automatically have good "public relations." And in this case it also usually follows that as long as the expert doesn't stick his nose into company business and try to find out what makes the company "tick," he has a job for life. In too many cases, the relationship a company enjoys with the public—as long as it doesn't immediately show in the balance sheet—is a minor matter to management. However, even this is shortsighted for under our competitive system, ultimately the lack of public approval will show in red on the balance sheet.

The person responsible for public relations in any company has to be close to the top management of that company. He has to be taken into confidence be-

*Address by Mr. Taylor upon receipt of the annual award of the American Council on Public Relations, San Francisco, February 4, 1947.

How to *Rate a Swivel!*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Curve based on 100 R. P. M.
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AVERAGE BEARING LIFE — HOURS AT 100 R. P. M.
TYPICAL CURVE SHOWING EFFECT OF ROTATING SPEED ON BEARING RATING
Curve based on 100% rating at 100 R. P. M.
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REVOLUTIONS PER MINUTE
"OILWELL"

WEIGHT of the drill-pipe string and speed of rotation are important factors in determining the service-life that can be expected from any swivel.

THESE RATING CURVES show you why swivels which have bearing load ratings sufficiently in excess of anticipated operating loads prove more economical in operation and give longer trouble-free performance than do swivels operated at, or near, their maximum load capacity.

"Oilwell" Swivels . . . are designed in four sizes to give you the capacity you should have to meet different drilling requirements. Regardless of size, your "Oilwell" Swivel embodies field-proved design principles which result in minimum friction loss and bearing wear.

THEIR ABILITY to perform satisfactorily on so many of the world's deeper wells is convincing proof that "Oilwell" Swivels can be depended upon to give long, trouble-free service and assure you of outstanding operating economy on every drilling job.

CHECK UP CAREFULLY before selecting your next swivel. "Oilwell" representatives will be glad to help you make a thorough analysis of your operating conditions and select the swivel indicated to safely meet your drilling requirements.

OIL WELL SUPPLY COMPANY

Branches Serving All Oil Fields

Executive Office—Dallas, Texas
Export Division Office—
30 Rockefeller Plaza
New York 20, N. Y.

Division Offices—Columbus, Ohio
Dallas, Texas . . . Denver, Colorado
Houston, Texas. .Tulsa, Oklahoma
Los Angeles, California

UNITED STATES STEEL

"Oilwell" Swivel Number	*Dead-Load Rating-Tons*	**Swivel Rating Recommendation-Feet*
No. 60-C	100	5,700
No. 100-C	200	8,500
No. 150-C	300	12,500
No. 300-D	400	17,000

***Recommended for drilling depths as indicated with 4½" Drill Pipe at 100 R.P.M.**

"OILWELL"

cause, above all else, he must know what goes on in the company before he can do an intelligent job of reporting.

If the American industrial system is going to be sold to the public, the persons doing the job must first af all believe it is good. Everyone knows that business is run for a profit just as the ordinary working man works for more than a bare subsistence.

But take profits for an example. Along with a lot of other subjects, profits must be taken out of the "secret" class if the public is to begin to understand the American corporate system. The public is perfectly justified in asking what management has to hide in the maze of figures surrounding, and often obscuring, what could be a simple explanation of corporate financial statements.

Well, does management have anything to hide? In 99 cases out of 100, it's just lack of insight on the part of management, with perhaps a little laziness thrown in to boot. In other words, maybe they typify that favorite old expression of mine—"40 years before the public but 100 years behind the times." Now I'm not talking about a discussion of competitive trade secrets. I'm talking about overall policies that guide a company. The contributions that a company makes to the community or nation, the reasons why the company is in business, how it distributes monies received, and, all in all, pretty much everything management does, should be able to stand the careful scrutiny of the public. For public opinion is one of the best tests of management policies. If a policy isn't going to stand careful scrutiny by the public, it isn't a good one. No amount of talking is going to sell the people on policies and programs that are contrary to public interest. It must be one of public relations primary functions to see to it that policies are established in the public interest, that the company recognize its duty to the public, and again this leads right back to top management. If public relations is undertaken with anything other than complete honesty, it becomes a charlatan effort to fool the public and you can't do this for very long. You have to have a factual and honest story to tell and then tell it.

Every way we turn, we seem to return to a basic premise that good public relations are management's responsibility; however, there have been others just as short-sighted as management.

Advertising agencies, for example, have been noticeably lax in selling management on the value of good public relations. In many ways, they have been so busy selling the milk, they have neglected the cow. The clink of cash in the till seems to blot out the fact that there's a real job to be done.

Agencies seem to be waking up to the seriousness of the public's mistrust of business. One would have thought that they, of all people, would have been the first to see the need for good industrial public relations. Industry under any system is going to manufacture and distribuate, but when there is no competition, advertising agencies cease to exist.

If the public has only one brand of product from which to choose, there is no need for product advertising. Under such a monopolistic set-up, whether private or brought about by government regulations, an advertising agency would be able to perform in a very limited capacity, if at all. Complete government ownership would mean that all public relations and advertising people, if they wanted to stay in the business, would have to become political propagandists and punch a time clock in some government office building.

It's all very well for me to say that agencies should sell management on telling the story of our economic system to the public, or that you as public relations people should do the job, but how? That's the question.

In the first place, an agency account executive or public relations counsellor has to be a pretty effective salesman to hold down his job. You've already sold management something or they wouldn't have hired you or your services. In other words, you've already got your foot and shoulder inside the door.

As I said before, to sell our way of life—our industry—our profession—or our company, we really have to believe in it ourselves. Well, do you? Do you actually thing the American way is the best way there is? If you do, you should be able to sell its preservation to management.

To be sure, you will probably disagree and argue with the boss. Maybe he'll tell you that, "We've gotten along so far without your ideas, and we'll continue to get along." But this is a job of selling, convincing, and persuading. You have to lead the way and educate—to teach and preach. It may take time. There will be discussions and disagreements but if you have sincere belief and are a salesman, there isn't a happier combination for doing a selling job.

After you have closed your sale and management is ready to undertake an honest public relations effort, what then?

Then you become that person I mentioned before "who has to be close to, or a part of, management." You examine every part of that company until you know it like the palm of your own hand —until you know its policies better than your own thoughts. All phases of its activities you measure in their effect on the public mind, for this is the real test of policies. The picture the public has of a company can be only as good as that company's policies.

When all this is a part of you and your thinking, the next job is to inform the public.

The company's employes are a part of the public. Do they know what the company contributes to the general economy? Do they know what percentage of income goes to wages and what is classed as profit? Do they understand the effect of capital investment on their jobs—that when capital has an incentive to invest more per employe that this helps to raise the employe's standard of living, shorten his working hours, and improve working conditions? Do the employes know that capital and labor together form the team—that one without the other can never prosper? Do they know how their standard of living compares with one provided by a similar industry in, say Russia, for example? Do they realize the part our free, competitive system of enterprise has played in making America great?

Employes of a company are potentially the greatest selling force American industry has, but, like a lot of other people, they have not been accurately informed either regarding the functions of American industry.

Consider a company's shareholders. Do they take an interest in the company beyond their dividend checks? It's good public relations to see that they do. For here again, they can be close to the company and as such, be vocal supporters of not only the company, but the system that makes it possible.

Do you ever think of customers beyond the point where they sign on the dotted line or lay a dollar on the counter? Practically every individual is somebody's customer. They have a right to know where their dollar goes. They have a real and personal interest in the economic system that provides them with the necessities of life. A customer—and that means all of us—has a right to know that this system of our provides the best. If beyond buying the product, they like the company and like the way of life that allows that company to operate, they become a vocal selling force. The customer is more than just a dollar sign in a ledger. The customer is all of the American public.

We can go on down the list—suppliers, other corporations in the same industry, dealers, transporters, and so on. Beyond that, lies the great mass of American people who are probably uninterested in your individual company, but who are aware of your industry and the American economic system.

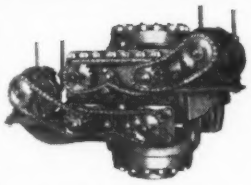
No one corporation, industry, or profession, can begin to do all the work. The great mass of American people are some one individual company's employes, or its shareholders, customers, suppliers, dealers, or so on. They all tie in and are dependent upon one another. Everything that America is today—its wealth and its greatness—it owes to the economy and system set up by our forefathers. This incentive to grow, to expand, to improve our positions in life, must be protected.

The high standard of living enjoyed by Americans has been created for and by themselves. They have produced the goods that no other nation could produce. The individual American working man has done these things and, all to often, he doesn't realize why or how. Because he isn't being constantly informed and because the phony promises of foreign ideologies are being dinned into his ears, he sometimes doesn't appreciate his heritage. He doesn't always know what this country has that no other country has. Someone has to tell him.

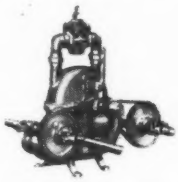
That's up to you. ★★★

Take your choice...

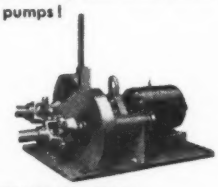
Air-Hydraulic-Electric-Steam or Manual!



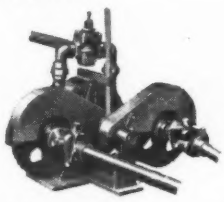
AIR DRIVE Most of today's drilling rigs are equipped with an air supply. By means of a compact quick-acting air motor, Shaffer Gates can be closed or opened at the turn of a lever!



HYDRAULIC DRIVE Practically every rotary rig has available an ample supply of drilling mud under pressure. By simply hooking an ingenious Shaffer-developed mud turbine to your Shaffer Gates you can operate them direct from the mud pumps!



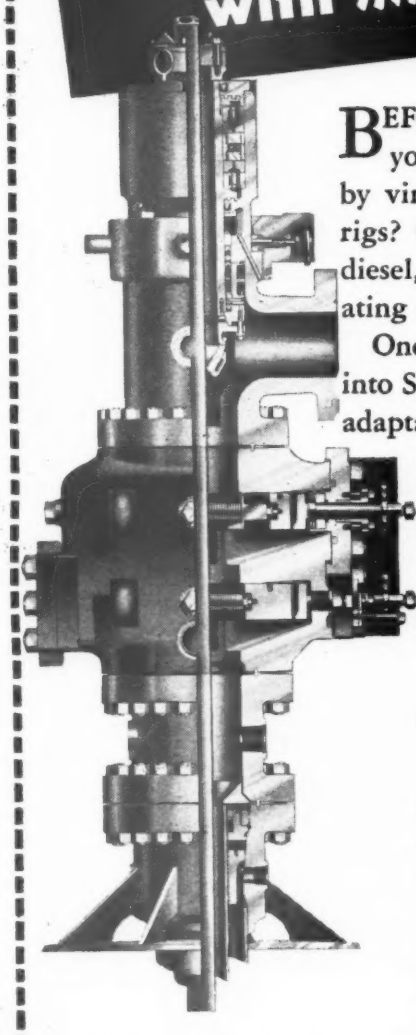
ELECTRIC DRIVE Or you can hook your Shaffer Control Gates directly to any 220 volt electric supply, if desired. Completely enclosed and protected motors assure instant gate operation at the flick of a switch!



STEAM DRIVE On steam-driven rigs you may prefer to operate your gates directly from the steam supply . . . a type of drive easily accomplished with Shaffer Gates by means of a compact steam turbine!

MANUAL DRIVE And one of the most important points to keep in mind is that Shaffer Gates—in addition to any type of power drive—can be quickly opened or closed by *manual* operation. Regardless of emergencies, you always have manual standby. No other equipment gives such complete protection!

You can operate SHAFFER CONTROL GATES with *ANY* type of power



The Shaffer Double Gate with the Shaffer Combination Rotating Blow-Out Preventer and Stripper and Shaffer Landing Base Head

BEFORE YOU buy cellar control equipment ask yourself this question, "Can the gate be operated by virtually *any* type of power found on today's rigs? Can it be moved from rig to rig—whether diesel, electric, steam or other types—without operating difficulties or undue complications?"

One of the many vital advantages engineered into Shaffer Cellar Control Gates is their universal adaptability to practically any type of operating requirement encountered in today's drilling jobs. Because their rams are opened and closed by *positive* mechanical drive, Shaffer Gates can be direct-connected to any of a wide range of operating drives. These drives are simple, inexpensive, compact and unusually efficient.

DIFFERENT DRIVES INTERCHANGEABLE ON THE SAME SHAFFER GATE!

Here's another important point to remember . . . If your original Shaffer installation was steam-driven, for example, and you later move to a diesel, electric or other type of rig, simply switch the power drive—an easy, inexpensive change—and continue using the *same* Shaffer Gate. This assures maximum utility from your investment in Shaffer Cellar Control Gates regardless of changes in drilling locations or facilities!

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS, Brea, California • California Service Shops: Santa Fe Springs and Taft
HOUSTON, TEXAS, 6006 Navigation Blvd. • ODESSA, TEXAS, 1925 West Second Street
OKLAHOMA CITY, OKLAHOMA, Acme Oil Tool Company, 1001 S. E. 29th Street
CASPER, WYOMING, Mountain Sales and Service, 133 North Wolcott Street
EXPORT SALES OFFICE: Shaffer Tool Works, 30 Rockefeller Plaza, New York, N. Y., U. S. A.

The Shaffer feature outlined above is only one of *many* unique advantages engineered into Shaffer Gates. They are unusually compact . . . are positive and foolproof in operation . . . their rams are easily and quickly changed . . . and there are many other advantages. Get the full story from your Shaffer representative . . . or write direct!

SEND FOR THE SHAFFER CATALOG!

See pages 3455 to 3506 of your Composite Catalog for information on Shaffer equipment.

Compete for prizes

More than 50 Rice Institute senior engineering students will compete for $100 in cash prizes for the best paper on "My Trip Through Tesco" after making an extensive tour through Texas Electric Steel Casting Company, Houston, Texas, one of the most modern steel foundries in the South.

First prize from Tesco will be $50, with second and third place papers to get $35 and $15, respectively, said Thomas H. Shartle, president.

John Doggett, Rice engineering instructor, headed the party of students. The trip through Tesco is sponsored annually for engineering students from various colleges in this area.

The Rice students were shown a motion picture of steel casting design and manufacture as part of the inspection trip.

Accompanying the Rice party through the plant were W. M. Ferguson, a Rice engineering graduate and now sales manager for Tesco, F. M. Wittlinger, secretary-treasurer, Allen Pike, sales representative, C. K. Tharp, general superintendent, and Guy Sherrill, metallurgist.

Chief engineer

Henry P. Reid, assistant to president, has been appointed chief engineer of the Universal Atlas Cement Company, United States Steel Corporation subsidiary, effective January 16, as announced by Blaine S. Smith, president of the company.

Reid has been associated with the company for 23 years, having served successively as special engineer, operating engineer, and, since 1942, as assistant to president.

Universal Atlas' Southwest plant is at Waco, Texas.

District manager

Republic Flow Meters Company, Chicago, Illinois, announces the appointment of Eugene N. Davidson as manager of its St. Louis District, which includes the eastern half of Missouri, southern half of Illinois, and western Kentucky.

Davidson is a mechanical engineering graduate of Texas Technological College. Previous to joining Republic he held engineering positions with General Electric Company and with Kellex Corporation. He goes to St. Louis after serving as a contract and application engineer with Republic Flow Meters Company and has engineered a variety of applications of Republic's controls, regulators, valves, and instruments.

Republic's office is at 812 Olive Street, (Room 480, Arcade Building), St. Louis 1, Missouri. The telephone is Garfield 5605.

LP-Gas storage

A further increase in standby facilities for the storage and use of liquefied petroleum gas is in prospect for Detroit gas users with the announcement by Stacey-Dresser Engineering, Cleveland, a division of Stacey Bros. Gas Construction Company, that it has been awarded a contract by the Michigan-Consolidated Gas Company to handle engineering and erection details of the new installation.

The original plant built last year by Stacey-Dresser engineers provided Detroit with an additional 20,000,000 cu ft of gas per day during the recent cold spell. The new facilities, to be provided at a cost of something over $1,000,000, will step up this capacity by another 30,000,000 or 40,000,000 cu ft per day.

When completed, the old and new installations together will consist of ninety-six 30,000-gal tanks and constitute the world's largest storage plant for liquefied petroleum gas serving the gas industry, according to E. A. Flaschar, general manager of Stacey-Dresser Engineering.

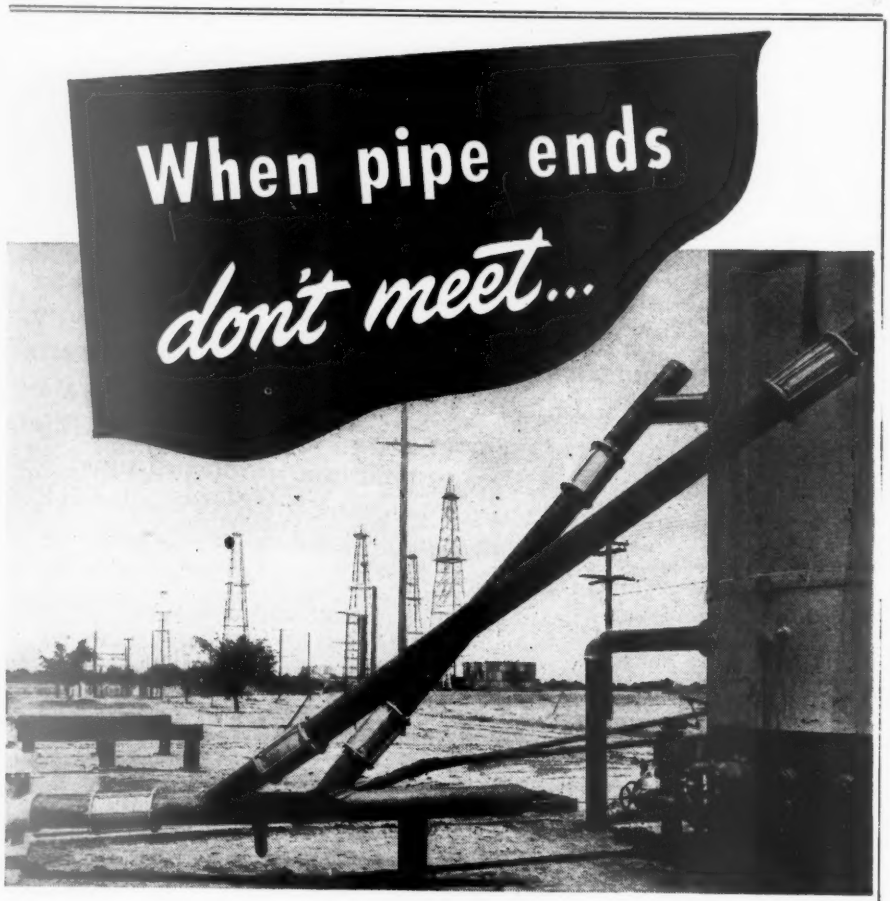
Advertising appointments

G. Reed Schreiner has been appointed assistant director of advertising of United States Steel Corporation of Delaware, it has been announced by David F. Austin, sales vice president. Schreiner, formerly advertising manager of Carnegie-Illinois Steel Corporation, succeeds Reese H. Price, who has resigned.

Simultaneously appointed was Robert J. Wilcox as acting advertising manager of Carnegie-Illinois succeeding Schreiner, it was announced by Thomas J. Hilliard, sales vice president of this United States Steel subsidiary.

Schreiner, University of Pittsburgh graduats in 1916, joined the Carnegie Steel Corpany advertising department in 1919. After serving in the Army during World War I, he became advertising manager of Carnegie-Illinois in 1938.

Wilcox, Geneva College graduate, joined Carnegie Steel in 1930 as a sales trainee and later served as assistant in sales training and in the stainless steel sales division. He joined the advertising division six years ago and for the last three years has been assistant to the advertising manager.



Dresser Long Sleeves join 'em tight

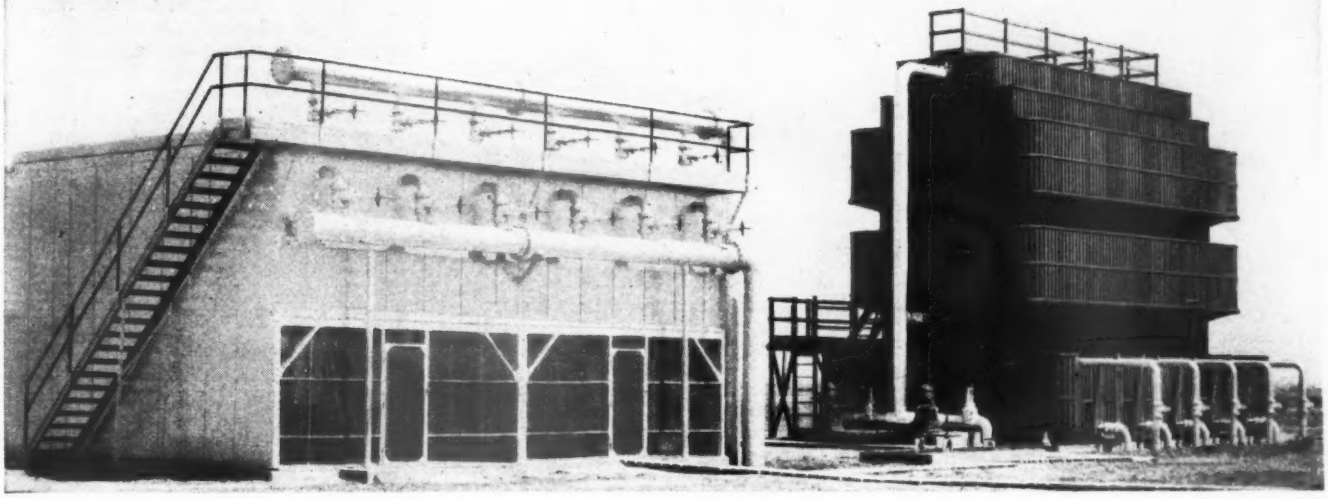
Want to speed up pipe joining at wells, separators, Christmas trees? Want to eliminate slow threading, exact lengths and lining up? Then get Dresser Long Sleeves (Style 40) from your oilfield supply store or our Houston warehouse. They span the gap, make tight, vibration-proof joints every time.

DRESSER STYLE 40 LONG SLEEVES

ONE OF THE DRESSER INDUSTRIES

Dresser Manufacturing Division, Bradford, Pennsylvania
Houston Warehouse, 1121 Rothwell St., Houston, Texas

TEAM-MATES...
not Competitors!



FLUOR

Aerator Cooling Towers

•

Counterflow Induced Draft Cooling Towers

•

FIN • FAN Cooling Units

WRITE FOR FLUOR GENERAL CATALOG NO. 46

The FLUOR FIN • FAN Cooling Unit, in combination with the FLUOR Aerator Cooling Tower, provides *complete* cooling service . . . particularly in locations where water is scarce. Cooling the lubricating oil and gas is essentially a job for the Cooling Tower, since the temperature to which they are to be cooled approaches the dry bulb temperature of the air. Jacket water cooling is, in most cases, a job which can be performed very economically by the FIN • FAN Heat Exchanger, since the temperature of the water cooled does not approach atmospheric dry bulb temperature too closely.

The installation shown above, at a Gas Compressor Station of a large Eastern Utility Company, is a typical example of this ideal combination on the job. If you have a problem pertaining to the cooling of water, oil or gas, FLUOR can be of unbiased assistance since FLUOR designs and builds Aerator Cooling Towers, Counterflow Induced Draft Cooling Towers and FIN • FAN Cooling Units.

BE SURE SINCE 1890 WITH FLUOR

FIN • FAN Cooling Units are manufactured and sold by: The Griscom-Russell Co. and The Fluor Corporation, Ltd.

FLUOR FIN • FAN COOLING UNIT

THE FLUOR CORPORATION, LTD., 2500 South Atlantic Boulevard, Los Angeles 22

NEW YORK • PITTSBURGH • KANSAS CITY • HOUSTON • TULSA • BOSTON

ENGINEERS • MANUFACTURERS • CONSTRUCTORS

Heads Kerotest

Walter G. Swaney

Walter G. Swaney was elected president of Kerotest Manufacturing Company, Pittsburgh, Pennsylvania, and Stanley J. Roush became executive vice president at a special meeting of the board of directors on January 23. Edward G. Mueller, former president, became chairman of the board. Other officers elected included A. W. Anderson, works manager and director of purchases, and Ralph E. Lane, secretary-treasurer.

Walter Swaney, Kerotest's new president, was one of the original members of the firm, having begun as a clerk in 1905. One of the company's first major contributions to the oil industry was the pioneer production of cast-steel gate valves. The change to cast-steel was developed to enable drillers to eliminate the huge cast-iron valves whose immense weight and bulk could be replaced by the stronger, streamlined cast-steel valve. At the same time kerosine hydrostatic testing of valve castings was introduced by the company and was so successful that the corporate name was changed in the middle twenties to Kerotest Manufacturing Company.

Kerotest's history in oil industry valves has been one of constant progress and development until today Kerotest is one of the outstanding producers of all types of oil-field valves and fittings, well control systems, and carbon and stainless steel valves for refinery service and related chemical processing.

Kerotest is also a leading producer of brass valves and fittings for the refrigeration and air conditioning industries and one of the best known manufacturers of brass valves and fittings for the LP-gas industry.

Baroid appointments

Baroid Sales Division, National Lead Company, announces that W. L. Heater, D. A. Sikes, and H. H. Farnham have been appointed assistants to the general manager of the division. Their headquarters will be in the Los Angeles office.

The following appointments likewise have been made: L. W. Huebel, manager, Gulf Coast division at Houston; E. W. Louden, field service manager at Houston; Fred B. Williams, manager, Pacific Coast division at Los Angeles; N. B. Thompson, assistant manager, Pacific Coast division at Los Angeles; A. G. Cramer, assistant manager, Gulf Coast division at Houston; J. H. Beesley, sales manager, Mid-Continent division at Tulsa; Dixon D. Powers, distribution supervisor, Gulf Coast division at Houston; K. K. Litman, Dallas sales representative, Dallas.

Together with J. W. Hofstetter, assistant to the general manager and comptroller, Heater, Sikes, and Farnham will supervise, under the direction of General Manager G. L. Ratcliffe, all activities of the division. W. L. Heater will have charge of purchases, non-drilling mud sales, and advertising. D. A. Sikes will have charge of drilling mud sales and field service. H. H. Farnham will have charge of research and development, testing equipment, and well logging.

Service pins awarded

Seven officials and employes who have completed at least 25 years of consecutive service with the Cummins Engine Company, Inc., were awarded gold recognition pins recently by the Service Award Committee at the factory in Columbus, Indiana.

A total of 445 pins and individual service certificates were presented to Cummins employes who had five or more years of consecutive service as of December 31, 1946. Additional pins and certificates will be awarded in the future as individual employes become eligible.

Members of the firm who received 25-year awards were C. L. Cummins, president; H. L. Knudsen, vice president in charge of engineering; Don J. Cummins, quality manager; Harry Voelz, Frank Fischvogt, Joe E. McCoy, and Ray Hammond.

Pins marking 20 years of service went to 12 employes; 15-year pins to 24, 10-year pins to approximately 100, and 5-year pins to more than 300 employes.

The gold pins, fashioned in the shape of the Cummins fuel injector, each bear two jewels, which indicate the number of years of service. The 25-year pins bear diamonds; 20-year pins pearls; 15-year pins rubies; 10-year pins emeralds, and 5-year pins sapphires.

Made manager

Announcement is made by American Car and Foundry Company that T. C. Ballou has been appointed manager of welded products sales and, as such, will be in charge of sales of weldments, and welded products other than tanks, pressure vessels, and cars of welded construction.

Establishes office

Nicholas A. D'Arcy, Jr., has established his own office at 7824 State Street, Huntington Park, California (KImball 6673), where he will represent Fawick Airflex Company, Inc., manufacturers of Airflex Clutches, and Torcon Corporation, manufacturers of Torcon hydraulic torque converters. He will devote his time to the proper selection and installation of Fawick and Torcon units in the oil industry.

N. A. D'Arcy, Jr.

D'Arcy is well known to all branches of the oil industry and his articles have appeared in *The Petroleum Engineer* on several occasions. He is a member of the Los Angeles Chapter of API, of the AIME, the ASME, and the Petroleum Production Pioneers, and has taken an active part in all these organizations.

He received his technical training at California Institute of Technology and has been connected with the oil industry since 1929. He was with Emsco Derrick and Equipment Company for 10 years and a partner of the Charles W. Carter Company, Los Angeles, for the last three years.

To Middle East

Joe A. Lyne, chief field engineer for Parkersburg Rig and Reel Company, Parkersburg, West Virginia, left recently for the Middle East via London to cover operations in those areas in the interest of his company.

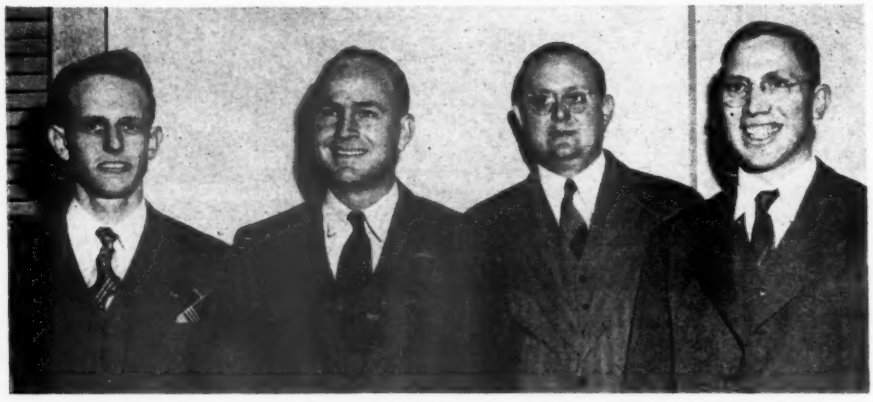
While serving Parkersburg as chief field engineer in domestic operations, Lyne also has for the last 15 years covered South American operations.

Opens new store

Jones and Laughlin Supply Company has opened a new store at Pauls Valley, Oklahoma. William D. Breedlove, formerly with the company's Seminole, Oklahoma, store, is store manager, and will operate as part of the central and southern Oklahoma district under L. R. Roberts, district manager, Wewoka, Oklahoma.

Jones and Laughlin also announces that R. A. Weber has recently been made field salesman in the Hutchinson, Kansas, area.

Officers North Texas A.I.M.E.



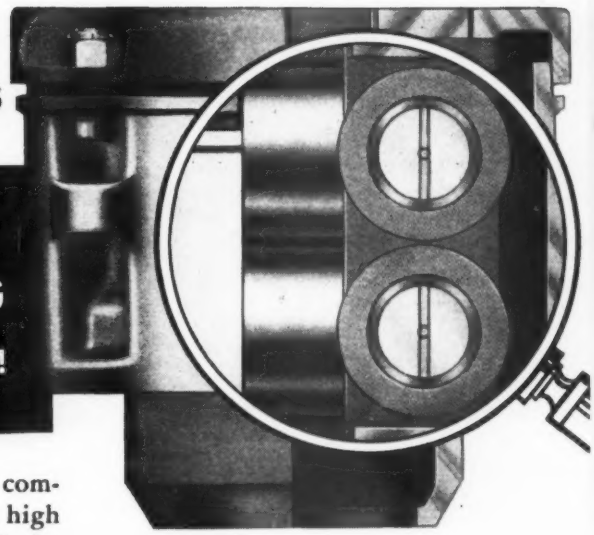
The newly elected officers of the North Texas Section of the A.I.M.E. for 1947 are, left to right: Gordon H. Fisher, Gulf Oil Corporation, Fort Worth, chairman; L. F. Peterson, vice chairman for Fort Worth, Stanolind Oil and Gas Company; E. B. Nicholson, vice chairman for Wichita Falls, Continental Oil Company, and E. R. Brownscombe, vice chairman for Dallas, Atlantic Refining.

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

OUR 27th YEAR

There's as much difference between this and this ...as between this and this



That's why the BAASH-ROSS ROLLER KELLY BUSHING makes 6 vital savings in drilling operations!

IF you want to know whether or not your rig operations are completely up-to-date *look at your kelly bushing.* If, under modern high speed drilling operations, you are still trying to *slide* the kelly through the bushing instead of *roll* it through, you're bucking the same kind of friction you'd get by dragging a load of drill pipe instead of rolling it on wheels.

Here's why: Some operators think that, because the drill string is hanging vertically in the rig, it will drop through the table without friction when the weight is fed off. It will—*as long as no driving pressure is being applied by the rotary table.* But as soon as the table starts rotating the drill string, pressure is built up between the bushing and kelly... pressure that becomes greater and greater as table speeds and the length of the drill string increase.

This driving pressure becomes so great under today's high speed drilling operations that the kelly simply cannot feed off freely when the brake is lifted. Bit feed becomes jerky and erratic. Too much weight is applied... the bit "digs in"... and the damaging torsional loads set up in the drill string cause costly "twist-offs" and pin failures. In addition, table and swivel bearings are subjected to surging impact loads and the life of virtually every piece of equipment in the drill string is substantially shortened.

But—WITH A BAASH-ROSS ROLLER KELLY BUSHING the rollers insure instant response to kelly feed *regardless of driving pressure between bushing and kelly.* Instant response means accurate weight control... faster drilling... straighter hole... and minimum torsional loads to damage the drill string or rig equipment.

When you put a Baash-Ross Roller Kelly Bushing on your rig you can count on making at least 6 important savings...

1. **MORE ACCURATE WEIGHT CONTROL** because—even at table speeds as high as 1000 r.p.m.—there is no friction between bushing and kelly to hold up the drill string or prevent instant weight response.
2. **STRAIGHTER HOLE** because bit feed is controlled more accurately and excessive weight is eliminated.
3. **MORE HOLE PER BIT** because the bit can be kept digging at a more uniform and efficient rate without damaging load surges.
4. **REDUCED DRILLING COSTS** because longer bit life means more time on bottom, less time wasted on round trips.
5. **MINIMUM DRILL STRING DAMAGE** because sensitive roller kelly feed eliminates over-feeding and the sudden torsional loads that cause twist-offs and thread damage.
6. **MAXIMUM EQUIPMENT LIFE** because drilling lines, swivel and table bearings, and other rig equipment are all protected against the destructive impacts of over-feeding.

ADVANCED CONSTRUCTION FEATURES

Baash-Ross pioneered the roller kelly bushing principle and through the years has made one important design advancement after another that insures maximum service life and minimum maintenance on even the heaviest drilling service. • Two Rollers against *each* kelly face prevent wobble and gyration of the drill string • Replaceable Bronze Bushings between rollers and pins take practically all the wear • Reversible Pins can be rotated to double the life of the pins • Solid One Piece Cover is completely streamlined for maximum safety and strength • Positive Shim Adjustment in hex kelly bushings simplifies maintaining the proper clearance essential with hexagonal kellys... These and many other features mean maximum operating efficiency and long service life when you install a Baash-Ross Roller Kelly Bushing.

Why not investigate *today* the multiple savings you can make in your drilling operations by installing a Baash-Ross Roller Kelly Bushing. They are available in sizes to fit all popular kellys from 2½" to 6" in the square type... from 3" to 7" in the hexagonal type. Each size Bushing can be quickly adapted to a wide range of kelly sizes by simply changing roller assemblies, thus minimizing inventories and simplifying changes in kelly sizes.

Get all the facts from your Baash-Ross representative on the many savings you can make by installing a Baash-Ross Roller Kelly Bushing. Or write direct.

Los Angeles office

The Marley Company, Inc., Kansas City, Kansas, manufacturers of spray nozzles, cooling towers, and other water cooling equipment, announces the opening of a Los Angeles office at 303 Continental Building, 408 South Spring Street.

A. C. Elias

Arthur C. Elias, factory engineer, supervised the opening of the branch office during the latter part of January. The new office will serve greater Los Angeles and all of southern California. Other sales offices and representatives of The Marley Company are in principal cities of the United States.

Personnel director

A. J. Adams has recently been appointed personnel director for the Houston Oil Field Material Company, Inc. Adams joined Homco in September, 1937, as warehouseman. He was later transferred into the general office and worked there until the industrial sales department was organized in 1942. He went to work in this newly organized department as a telephone salesman and continued in that capacity until he joined the United States Armed Forces on July 10, 1942.

After his separation from the Army he returned to Homco on June 20, 1946, as assistant personnel director, and was recently appointed to his present position of personnel director, succeeding H. P. Edmundson. Edmundson has been transferred to the sales department.

Heads foreign business

The board of directors of Worthington Pump and Machinery Corporation, Harrison, New Jersey, has elected S. Riley Williams vice president in charge of foreign business.

S. Riley Williams

Williams joined the Worthington organization in 1920, immediately following his release from the United States Army, where he served as a first lieutenant in World War I. From 1920 until 1941 he resided in Europe, where he was successively managing director of the Worthington Associated Company in Spain, of its associated company in France, and general European manager. In 1941 he returned to the United States, and during the recent war served as assistant to the vice president in charge of operations. In May, 1945, he was appointed director of international business.

In his new capacity he will have responsibility for the sale of Worthington products for export, as well as the administration of Worthington Associated Companies in South America and Europe. He will make his headquarters at the Worthington home office in Harrison, New Jersey.

South American services

Two well-known figures in oil circles—William S. Waldrip, owner of Waldrip Engineering Company of Los Angeles and W. J. Campbell, president of the Petroleum Machinery Corporation of New York City—have formed the C. A. Industrias Waldrip Y Campbell with head offices at Caracas, Venezuela. Modern plants to serve both eastern and western Venezuela oil fields have been established at Maracaibo and Barcelona where complete facilities are maintained for repairs and maintenance of all classes of oil field and refinery equipment. In addition, both plants have electric repair departments and acetylene and oxygen plants. The company represents Air Reduction Sales, and other manufacturers in both Venezuela and Colombia.

W. S. Waldrip

William S. Sprague, a well-known Los Angeles attorney, is the new president of Waldrip Engineering Company and heads the board of directors, which also includes the following: Clifford E. Sommarstrom, James Moon, Archie D. Fuller, and William E. Schrader.

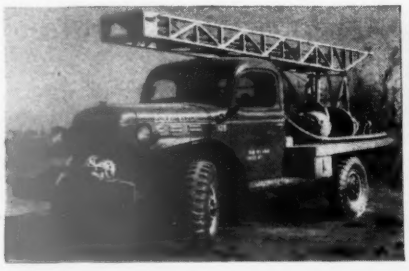
In addition to manufacturing crown and traveling blocks, a complete line of production machinery and other items in the drilling field, the company is now in production on its new line of portable drilling masts and self-propelled and trailer mounted servicing rigs.

CORE-DRILLING RIG—Powered by

WISCONSIN Heavy-Duty Air-Cooled ENGINE

When the Rogers-Ray Company, of Houston, Texas, designed and built this unique rig for use in drilling core holes in geophysical work . . . especially in South America . . . one of the primary considerations was to secure a thoroughly dependable, heavy-duty power unit. Quite logically, the choice was a 4-cycle, 4-cylinder, V-type Model VE-4 WISCONSIN Air-Cooled Engine . . . service-proved in all climates, under all weather and operating conditions.

Wisconsin Air-Cooled Engines are supplied in a complete power range, from 2 to 30 hp., single cylinder and 4-cylinder types.



WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.

Buys firm

Le Roi Company, Milwaukee, Wisconsin, manufacturers of internal-combustion engines, portable compressors, engine-generator sets, and specialized mowing equipment, announces the purchase of the Cleveland Rock Drill Company of Cleveland, Ohio.

The purchase of this company, a division of The Cleveland Pneumatic Tool Company, substantially accelerates the rock drill manufacturing program announced earlier, coincidental with the establishment of Le Roi's Cleveland division. Included in the purchase were the manufacturing rights to all the line of rock drills, the jigs, dies, fixtures, patterns, etc, as well as the complete inventory of parts for their manufacture.

Russ Morgan, formerly secretary and sales manager of The Cleveland Rock Drill Company, who joined Le Roi more than a year ago and who was instrumental in the organization of Le Roi's Cleveland division, will head the expanded facilities. Morgan has brought his staff with him to Le Roi Company.

John M. Dolan, vice president in charge of sales, will head the integration of sales activities of all Le Roi products from the company's headquarters at Milwaukee. Dolan reports a substantial strengthening of Le Roi's position in the construction industry by this move, a complete line of rock drills of all sizes for every requirement being closely related to both distribution and application of the company's extensive series of compressors. Expanded field activities will utilize the company's district offices at New York, Birmingham, Washington, Milwaukee, Tulsa, Butte, and San Francisco, to provide improved coverage to all classes of industry served. Overseas sales will be handled by the company's foreign sales department at Milwaukee.

Chemical engineer's meet

The first dinner meeting of the Oklahoma Local Section of the American Institute of Chemical Engineers for the 1947 season was held at Adams Cafe, Bartlesville, Oklahoma, on January 24. The meeting was attended by 43 members and guests.

John J. Riley, Jr., of the Spencer Chemical Company, spoke on the subject, "Peacetime Utilization of a War Plant." A movie covering the construction of the Jayhawk Ordnance Works was shown in conjunction with Riley's talk.

After Riley's talk, committee chairmen gave their annual reports and discussed the programs for the coming year.

The following men were elected as officers for the coming year: Chairman, Howard L. Malakoff; vice chairman, Virgil Scarth, and secretary-treasurer, Fred H. Poettmann.

In addition to the retiring chairman, H. R. Legatski, Lawrence K. Cecil, and Harrison L. Hays were elected to the executive committee.

POSITION WANTED—Mechanical engineer, college graduate, age 34, registered professional engineer Ohio. Member SAE. Eight years' experience oil field equipment design. Diesel electric locomotive maintenance specialist. One year engineering in mechanization of Gray Iron Foundry. Desires location in Southwest. Native Texan. State full particulars. Address Box 63, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

SITUATIONS OPEN: Chemical Engineers with three to five years experience in the operation of petroleum refining distillation units, thermal cracking units or catalytic cracking units for work as Technical Service representatives and Operators of commercial catalytic cracking plants. Kindly send details of experience and education. Snapshot (if available). Address Box No. 59, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

SOUTH AMERICA

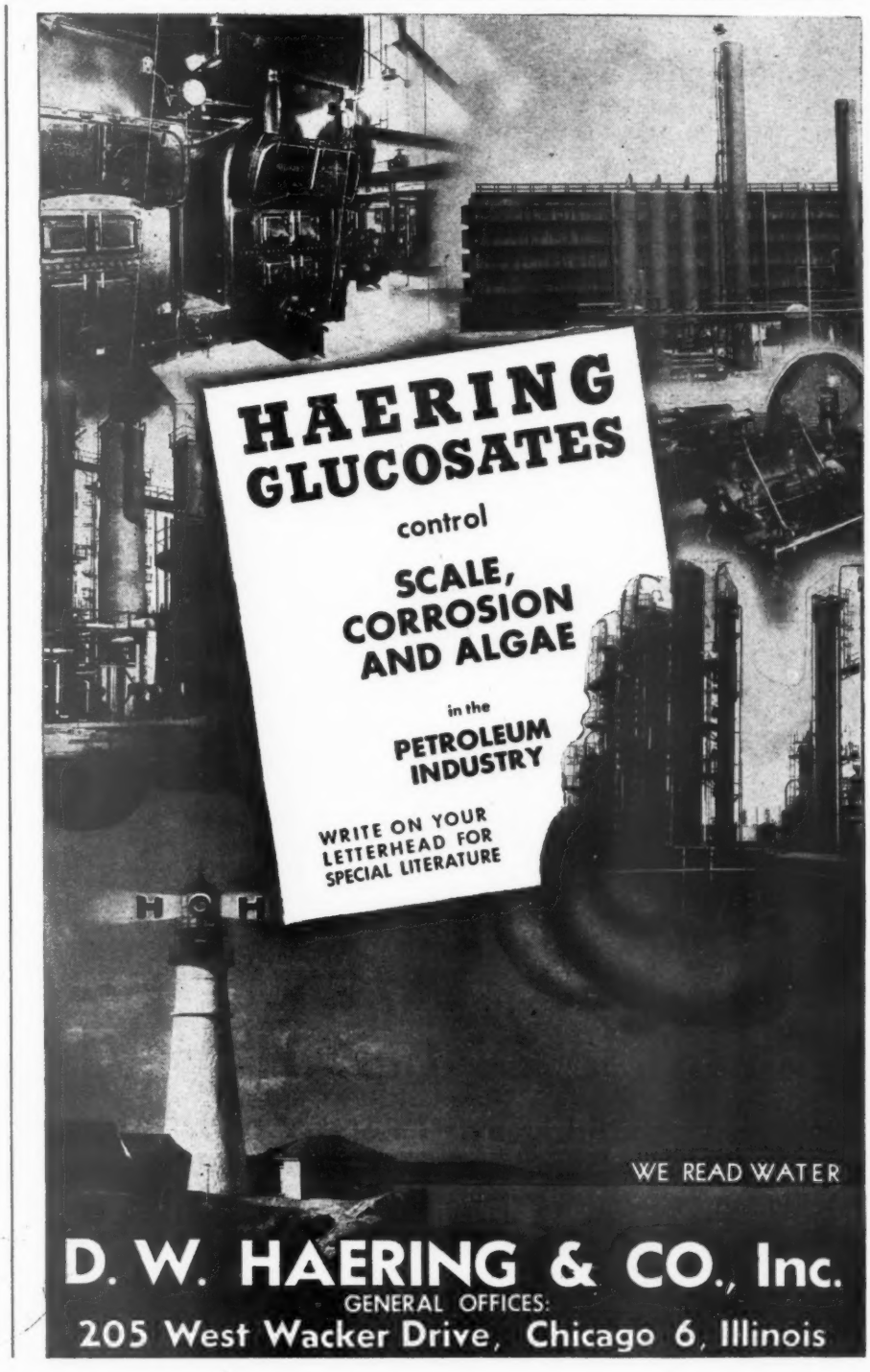
American company requires a number of petroleum engineers experienced in one or more of following phases: Reservoir, Drilling and Production, Laboratory, Mud, Equipment and Administration. Good salaries and job security offered exceptional men. Give complete details of experience. Box 64, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

WANTED—MECHANICAL OR METALLURGICAL ENGINEER—familiar with the inspection of refinery fractionating equipment, furnaces, heat exchangers and pressure vessels and having experience to qualify for making recommendations for renewal or repairs to the equipment. Experience on catalytic cracking units preferred, but not essential. In replying, please send full details of experience and education. Snapshot (if available). Box 62, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

FIELD GEOLOGIST—Caracas based, field work in Eastern Venezuela. To conduct independent surveys of detail and reconnaissance nature. Degree and 4 years' field experience. Knowledge of Spanish helpful. Minimum salary $500.00. Write brief details of education, experience, references to: The Atlantic Refining Co., Room 900, Box 7258, Philadelphia 1, Pennsylvania.

FOR SALE—Complete water purification unit. Brand new, capacity 80 gals. per minute. Also one water pumping unit, complete with two R-33 Continental Red Seal Engines, two 6" Centrifugal pumps, all necessary fittings. Atlas Supply Company, Box 1331, Bakersfield, California.

1—24", double 3 point Reamer for sale cheap. 1—3000 Gal. Butane Tank mounted on truck trailer, located at Vernal, Utah. Large stock of used oil well supplies. Send us your inquiries. Atlas Supply Company, Box 1331, Bakersfield, California.



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in Service, too!
Behind the *proved* dependability of your Cummins Diesels are reliable, conveniently located, exclusive Cummins Dealers . . . Cummins genuine parts . . . Cummins Diesel specialists . . . assuring you continued dependability.
CUMMINS DIESELS
SINCE 1918...PIONEER OF PROFITABLE POWER THROUGH HIGH SPEED DIESELS
CUMMINS ENGINE COMPANY, INC. • COLUMBUS, INDIANA

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 116

A VALUABLE and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their tenth year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions and improvements to existing tables by members of the pertoleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-14, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946 issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue

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Twin Disc Clutch Co. (sheet 5)	210	Feb.	P 501.731.

OIL AND PETROLEUM LOADING SIMPLIFIED BY BARCO SWIVEL AND FLEXIBLE ACTION

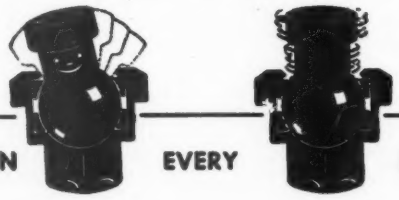
At refineries and bulk oil loading stations, Barco Flexible Joints are widely and successfully used for loading rack application. The chart above shows their easy adaptability for gravity unloading from tank cars. Providing both swivel and flexible action, Barco Joints used with the *new type Barco gaskets* give long, reliable service at normal temperatures on petroleum loading lines.

By compensating for expansion and contraction, these expertly engineered joints protect vital fluid lines against shock, vibration, strain. Write for information about the complete Barco line. Barco Manufacturing Co., Not Inc., 1825 Winnemac Avenue, Chicago 40, Illinois.

BARCO ***FLEXIBLE JOINTS***

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY



In Canada: The Holden Co., Ltd., Montreal, Canada.

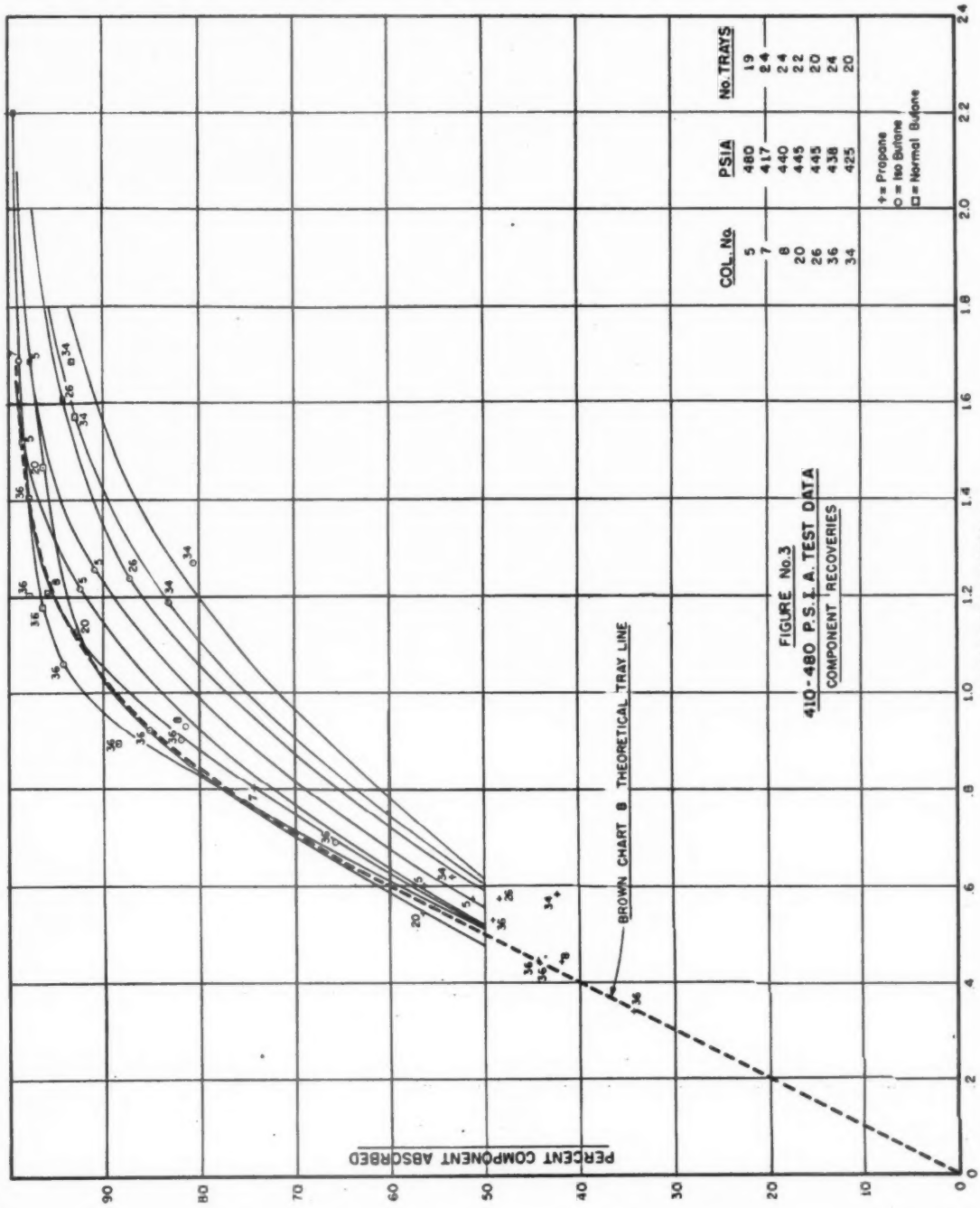
"MOVE IN EVERY DIRECTION"

EVALUATION OF ABSORBER OPERATING EFFICIENCY

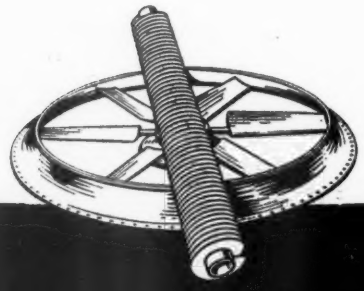
Both the top and bottom "A" factors are calculated from K factors based on the temperature of the fat oil leaving the bottom of the column. Justification for this simplification lies both in the character of the temperature gradient existing through the average absorber, and the fact that it has proved thoroughly workable in practice.

Having decided on a method for determining A_o (Sheet 2), component recoveries indicated by the test data were then calculated and plotted in the conventional manner on rectangular coordinate group-charts against appropriate A_e's—with each group chart being confined to a comparatively narrow operating pressure range. Figs. 2 and 3 are typical of these group plottings, and cover respectively 40-75 psia test data (Sheet 2), and 410-480 psia test data. For comparison, we also plotted on these group charts the Brown curve for an 8-tray theoretical column.

(For further explanation, see other sheets of this series.)



—Taken from the article by E. G. Ragatz and J. A. Richardson in the December, 1946, issue of The Petroleum Engineer, pages 53-58, inclusive.



FIN-FAN *Air-Cooled* HEAT EXCHANGER

for every cooling and condensing service

Jacket water, lubricating oil, solutions and other liquids, air and other gases can all be cooled . . . steam, hydrocarbons and other vapors can all be condensed . . . *by air* . . . in the FIN-FAN Heat Exchanger, jointly developed by Fluor Corporation, Ltd. and The Griscom-Russell Co.

Think what this means to you in eliminating the complications, problems and expenses of a water supply system . . . no water piping, pumps, treatment, disposal or make-up; no corrosion, scaling, freeze-ups, or structural re-painting due to use of water.

The FIN-FAN Exchanger is strongly constructed and highly efficient. It may be placed in any convenient location, and its effectiveness is independent of the velocity or direction of the wind. It is simple, easy and economical to operate.

WRITE FOR BULLETIN

Investigate this fully-proven and widely used unit. Its design, construction, and many important advantages are fully described in Bulletin 1230 which will be sent on request.

THE GRISCOM-RUSSELL COMPANY
285 Madison Avenue, New York 17, N. Y.

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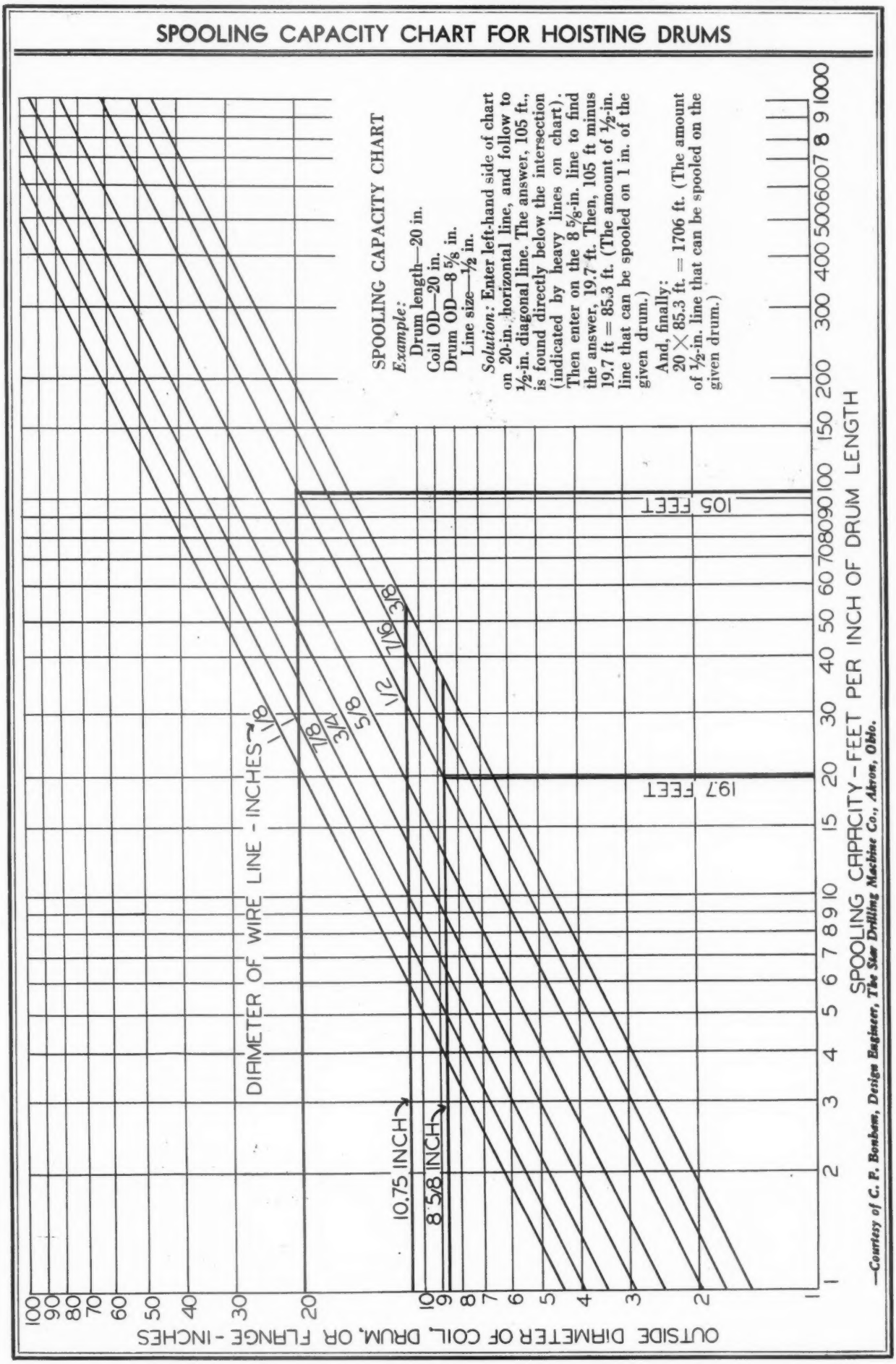
GRISCOM-RUSSELL

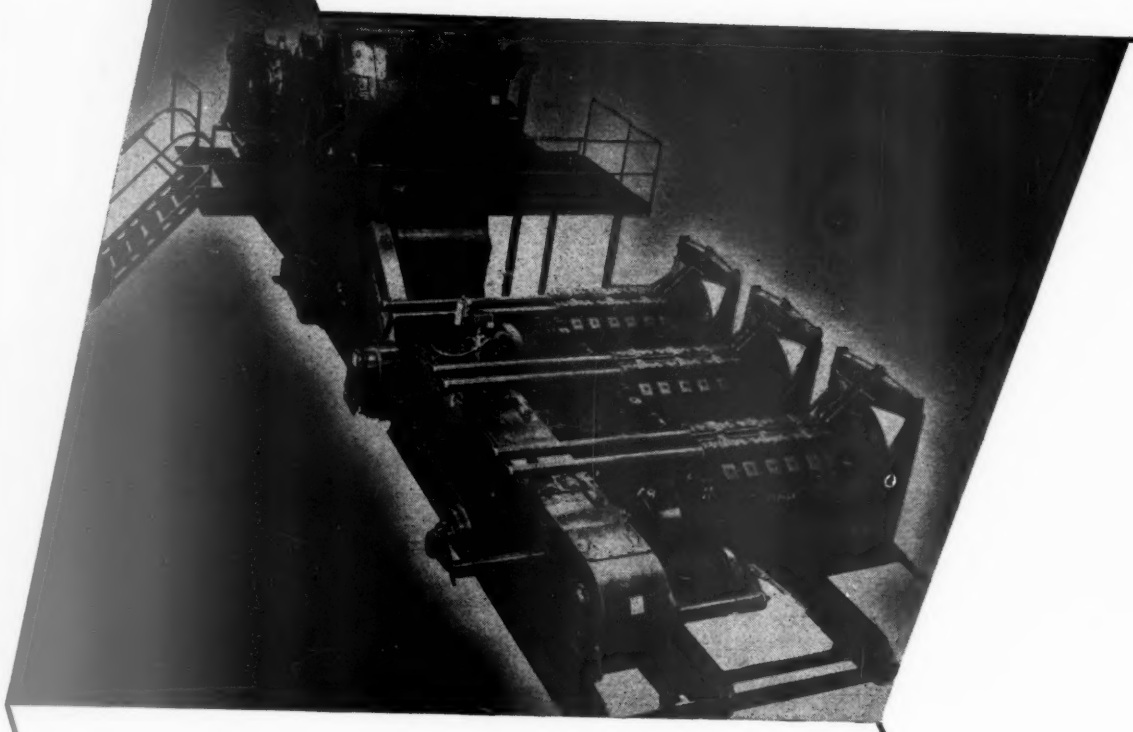
Pioneers in Heat Transfer Apparatus

SPOOLING CAPACITY CHART FOR HOISTING DRUMS


SPOOLING CAPACITY CHART
Example:
Drum length—20 in.
Coil OD—20 in.
Drum OD—8 5/8 in.
Line size—1/2 in.
Solution: Enter left-hand side of chart on 20-in. horizontal line, and follow to 1/2-in. diagonal line. The answer, 105 ft., is found directly below the intersection (indicated by heavy lines on chart). Then enter on the 8 5/8-in. line to find the answer, 19.7 ft. Then, 105 ft minus 19.7 ft = 85.3 ft. (The amount of 1/2-in. line that can be spooled on 1 in. of the given drum.)
And, finally:
20 × 85.3 ft. = 1706 ft. (The amount of 1/2-in. line that can be spooled on the given drum.)
105 FEET
19.7 FEET
DIAMETER OF WIRE LINE - INCHES
1/8
1
7/8
3/4
5/8
1/2
7/16
3/8
10.75 INCH
8 5/8 INCH
OUTSIDE DIAMETER OF COIL, DRUM, OR FLANGE - INCHES
SPOOLING CAPACITY - FEET PER INCH OF DRUM LENGTH

—Courtesy of C. P. Bonham, Design Engineer, The Star Drilling Machine Co., Akron, Ohio.

FOR FAST DRILLING



• CLIMAX V-12 ENGINES

Equipped with

• ENSIGN CARBURETION

Here's a combination hard to beat. Three fine engines synchronized and coupled up to a husky, sturdy drilling rig—easily a thousand horsepower at your finger tips.

We point with pride to this Ensign installation on Climax V-12 engines. It is an installation where carburetion plays a particularly important part — where instant starting and quick response to the governor demand correct ratios of air and fuel. For every change in engine load and speed these ratios must change automatically to conform without periods of over-richness or lean flat-spot operation.

The design and production of dependable carburetion receives our undivided attention. We have specialized in the field of industrial carburetion for over 35 years and shall be glad to share our experience with you.

ENSIGN CARBURETOR COMPANY

7010 SOUTH ALAMEDA STREET • P.O. BOX 229 • HUNTINGTON PARK, CALIFORNIA

BRANCH FACTORY: 2330 WEST 58th STREET, CHICAGO 36, ILLINOIS

"Pioneers in Efficient Carburetion" • Established 1911

EVALUATION OF ABSORBER OPERATING EFFICIENCY

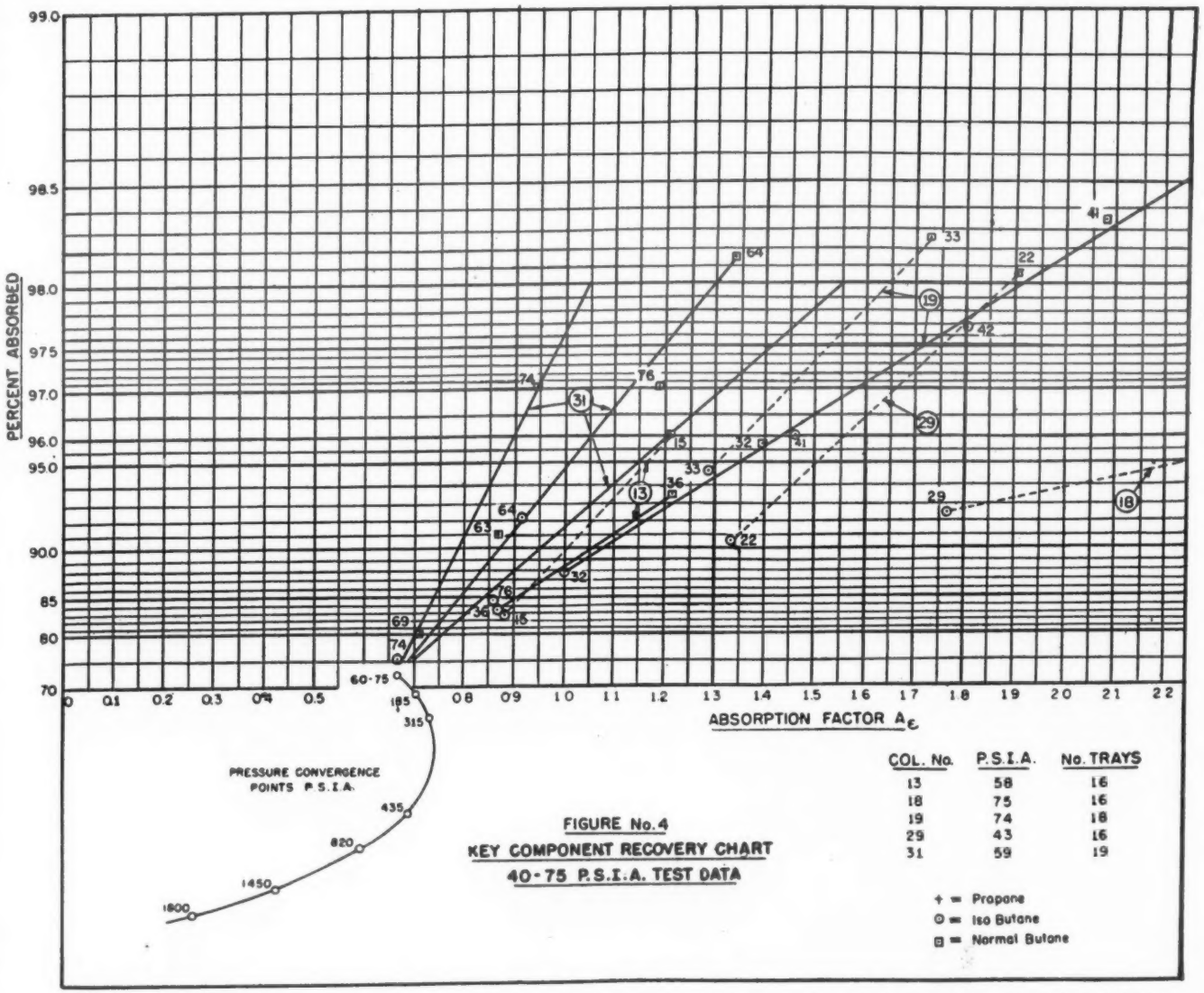


FIGURE No. 4
KEY COMPONENT RECOVERY CHART
40-75 P.S.I.A. TEST DATA

—Taken from the article by E. G. Ragatz and J. A. Richardson in the December, 1946, issue of The Petroleum Engineer, pages 53-58, inclusive.

Studyof these group plots (Figs. 2 and 3) brought out the following pertinent points:

1. Although the operating lines for the actual columns were of the same general nature as the theoretical tray lines, they departed materially from the theoretical in detail.

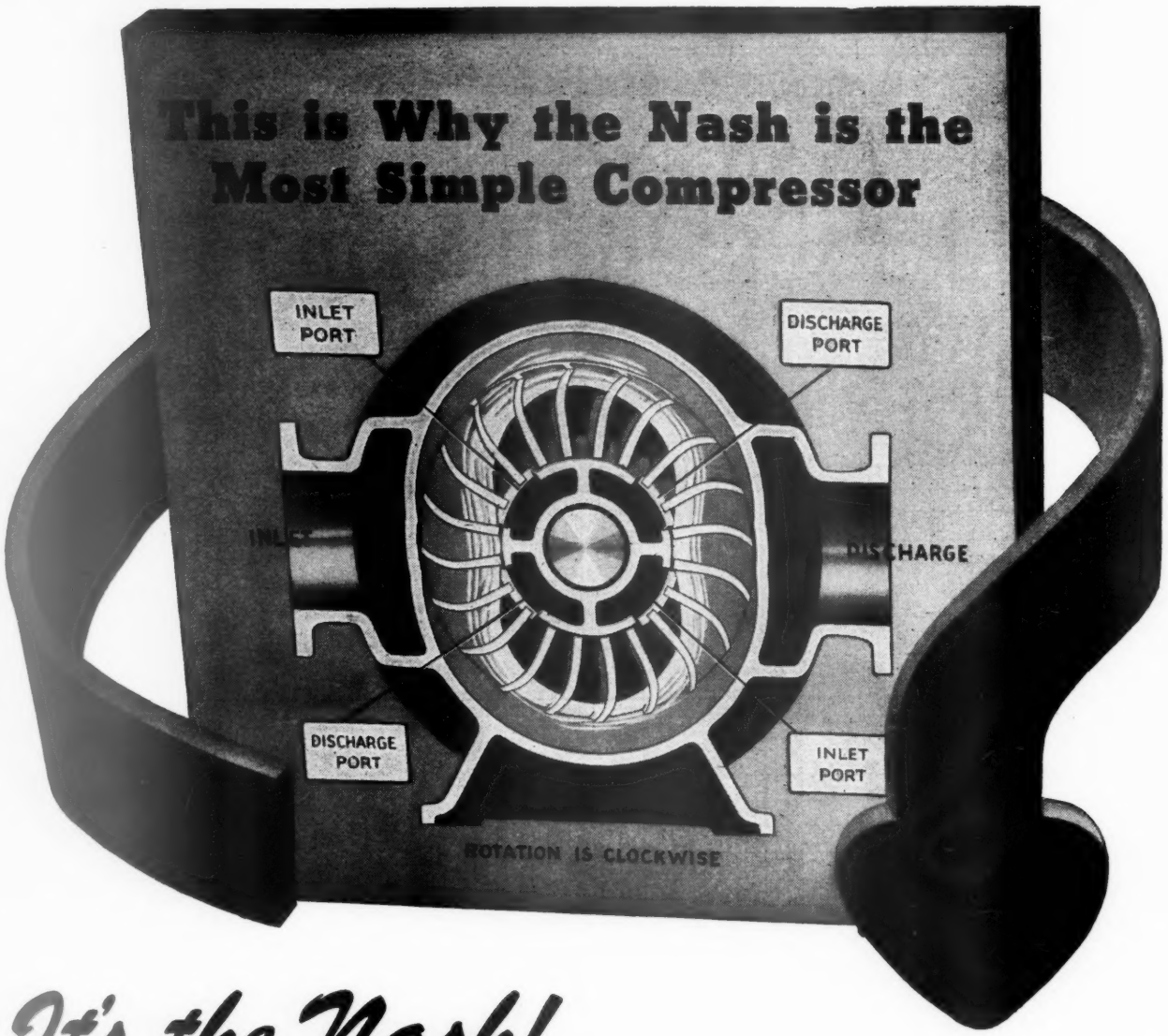
2. Individual test lines indicated marked column differences both in general tray effectiveness and relative component recoveries —with these differences often being evidenced by a criss-crossing of lines, rather than by a systematic line displacement as on the theoretical Brown chart.

3. The rectangular plotted operating lines were difficult to interpolate accurately in the critical 75-95 per cent recovery range due to rapid curvature in this region.

4. Although it was clearly evident that some of the column tests were much less authoritative than others, no reliable criteria of general operation pattern, or individual test consistency, was presented by the rectangular plots.

(For further explanation, see other sheets of this series.)

This is Why the Nash is the Most Simple Compressor



It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY
323 WILSON, SO. NORWALK, CONN.

EFFECT OF CRUDE GRAVITY ON PERFORMANCE OF GAS DRIVE RESERVOIRS

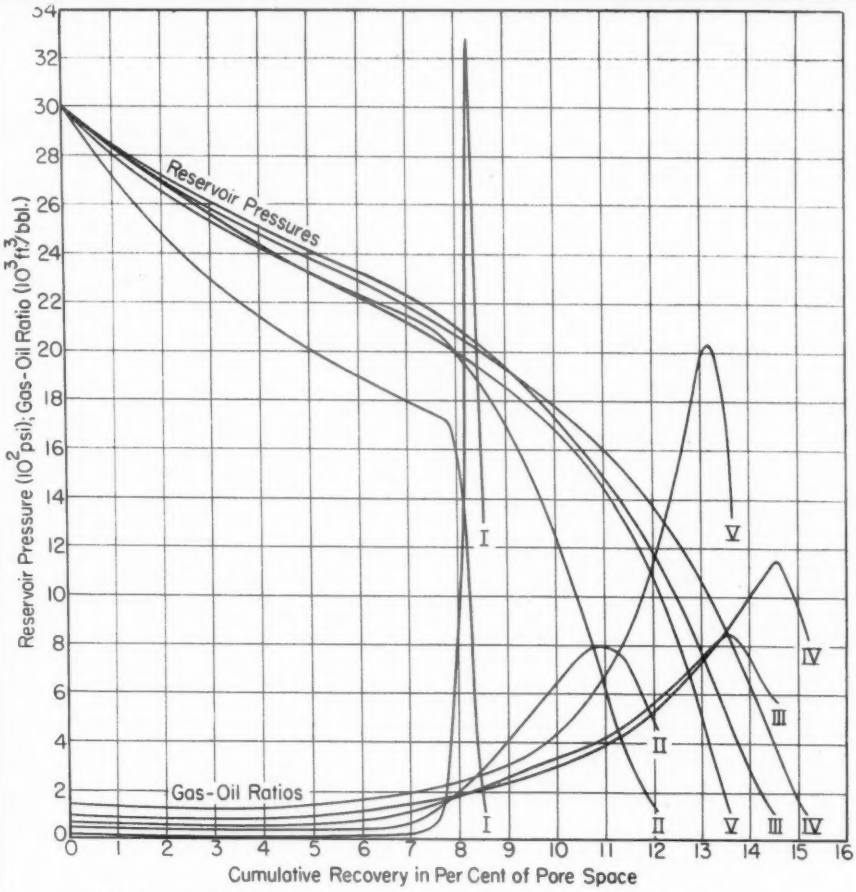


FIG. 10. Calculated pressure and gas-oil histories of gas drive reservoirs producing different API gravity crudes. Curves I: 10° API; Curves II: 20° API; Curves III: 30° API; Curves IV: 40°; Curves V: 50° API.

(This series of charts and data is taken from the exclusive article by Morris Muskat and M. O. Taylor, published in The Petroleum Engineer in December, 1946, pages 88-98, inclusive.)

The curves of Figs. 4 to 8 (see Sheets 2 and 3) provide the resultant reservoir fluid data required for the calculation of gas drive reservoir performance. The actual calculations were made by a numerical integration of the previously developed (see footnote below) differential equation, namely:

$$\left(1+\frac{\mu_o}{\mu_g}\psi\right)\frac{d\rho_o}{dp} = \rho_o\lambda + (1-\rho_w-\rho_o)\,\xi + \rho_o\eta\xi,$$

$$R = S + \alpha\psi(\rho_o), \quad . \quad . \quad . \quad (2)$$

in which it is assumed that the reservoir is subject neither to gravity drainage nor to significant water intrusion.

In equation (2), ρ_o is the oil saturation at any reservoir pressure, and the connate water saturation is ρ_w. R is the producing gas-oil ratio at any state of reservoir depletion and pressure, and the function ψ (ρ_o) is the ratio of the permeability to gas to that of oil. In all the calculations the connate water saturation was taken as 25 per cent. The results of the calculations are plotted in Figs. 10 to 12.

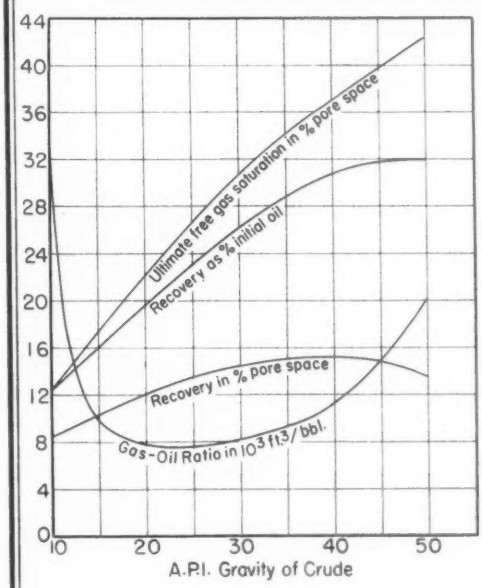

Ultimate free gas saturation in % pore space
Recovery as % initial oil
Recovery in % pore space
Gas-Oil Ratio in 10^3 ft^3/bbl.
A.P.I. Gravity of Crude

FIG. 11. Calculated ultimate recovery, free gas saturations, and maximum gas-oil ratios of gas drive reservoirs as functions of crude gravity.

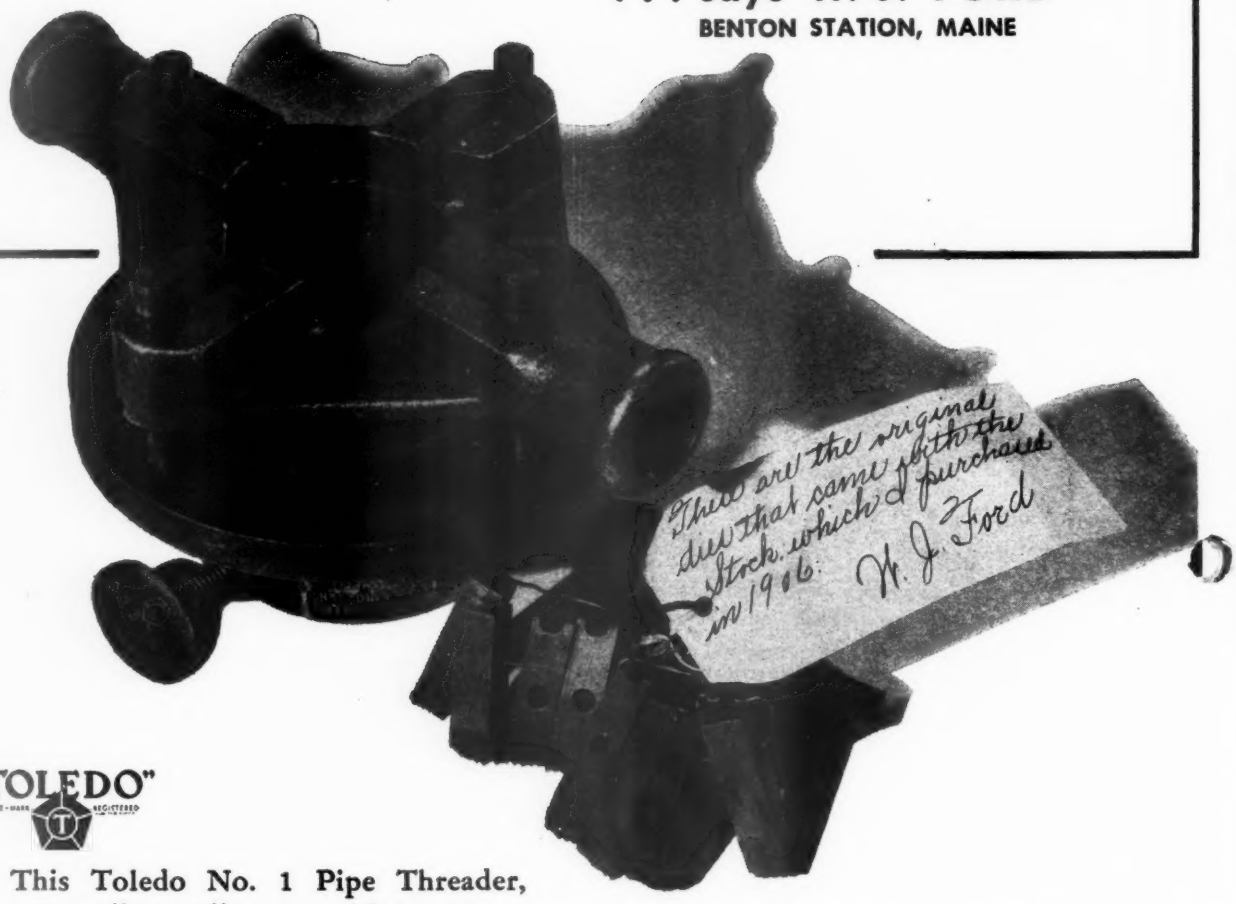
M. Muskat, *J. App. Physics, 16*, 147-59 (1945). It may be noted here that in this paper, equation (12), and in that of Muskat and Taylor (loc. cit.) equation (5), should be corrected by striking out γ from the coefficient of $\frac{d\beta}{dp}$. This typographical error affected in no way the numerical or general conclusions given in either paper, as the whole term involved dropped out in each case. In addition, however, the solubility of the gas in the residual oil in the gas cap was neglected. The correct equation taking this into account is:

$$\frac{d\rho_o}{dp} = \frac{\rho_o\lambda + (1-\rho_w-\rho_o)\,\xi + \rho_o\eta\left(\psi-\frac{rR}{\alpha}\right) + \overline{H}\left\{(1-\rho_w-\bar{\beta}\bar{\rho}_{oi})\,\xi - \bar{\rho}_{oi}\frac{d\bar{\beta}}{dp} + \bar{\rho}_{oi}\bar{\beta}\lambda\right\}}{1+\frac{\mu_o}{\mu_g}\left(\psi-\frac{rR}{\alpha}\right)}$$

in the notations of equations (1) and (2), and with $\overline{H}$ the ratio of gas cap to oil zone thicknesses, r the fraction of produced gas returned, and ρ_{oi} the residual stock tank equivalent oil saturation in the gas cap.

"This Toledo Threader in constant use SINCE 1906"

. . . says **W. J. FORD**
BENTON STATION, MAINE



"TOLEDO"

This Toledo No. 1 Pipe Threader, capacity 1″ to 2″, was sold by us on October 14, 1905, to a Boston distributor and purchased by W. J. Ford in 1906.

Mr. Ford says, "This stock was purchased in 1906 and has been in constant use ever since, but I cannot recall how many new sets of dies I have had to have in that time. *It has threaded pipe enough to reach three times around the world* and I am on the fourth lap now. When that is completed, I am going to retire and will ship the stock to you if you would like to have it to put on exhibition."

* * *

Today—the same basic principles of advanced design and quality construction keep Toledo Threaders the *preferred* tools of experienced mechanics everywhere! Get set with Toledo Threaders on *every* job—do it *better, faster* and *easier!* The Toledo Pipe Threading Machine Co., Toledo, O. New York Office, No. 2 Rector St. Bldg.

TOLEDO
PRECISION PIPE TOOLS

METHODS OF COMPUTING FLOW OF OIL IN PIPE LINES

IN the three previous installments we have seen that the general d'Arcy equation for pipe line flow, $h = f\frac{l v^2}{2 g d}$, can be reduced to an equation of the form $h = a B^n$. In this equation, B is the rate of flow in bbl. per hr., h is the hydraulic gradient in feet of liquid per 1000 ft. of pipe, n and a are constants for any specific grade of crude flowing in a given pipe diameter, provided the flow is turbulent and falls within commercially feasible limits for the given diameter.

One advantage of thus incorporating the friction factor, f, into the other constants is that direct solutions for rate of flow from a given hydraulic gradient become possible by a couple of operations on the log-log slide-rule. Another is the greater facility permitted in complex flow problems. For instance, consider Fig. 1-a, which is the profile of a three-battery gravity system from which oil is to be gathered into a field pump or suction pump of a station at point O.

Assuming no vacuum effect from the pump, it is obvious that any flow through the 2000 ft. of 8-in. pipe, L_o, will require a hydraulic gradient h_o, and that the elevation of the gradient, H_o, at Junction S will be $L_o h_o$. Similarly, any flow through the 1000 ft. of 4-in. pipe from Battery X will require a gradient h_1, and the elevation of the gradient at Battery X will be $L_o h_o$ plus $L_1 h_1$, or H_x. For flow through the 2000 ft. of 6-in., L_2, there must be a gradient h_2, and the elevation of the gradient at Junction T will be H_T, equal to $L_o h_o$ plus $L_2 h_2$; also, for flow from Battery Y through 1000 ft. of 6-in., L_3, there will be a gradient h_3, and the elevation of the gradient at Battery Y is $L_o h_o + L_2 h_2 + L_3 h_3$. At Battery Z, the elevation of the gradient is $L_o h_o + L_2 h_2 + L_4 h_4$.

It will be necessary to express these various values of h in terms of their respective flow rates, B, and since equations for a crude of 42-deg. API gravity and 35 SUS viscosity were derived in a previous article, we will assume that to be the grade in the tanks. These equations are:

For 4-in pipe

$h = 1/809\ B^{1.74}$ $\quad B = 46.73\ h^{0.57}$

For 6-in. pipe

$h = 1/7190\ B^{1.78}$ $\quad B = 145\ h^{0.56}$

For 8-in. pipe

$h = 1/32050\ B^{1.81}$ $\quad B = 308.6\ h^{0.55}$.

A rigorously precise solution of this problem would have to take into consideration the varying and unequal fall in oil levels of the three tanks. It would not be such a simple example of flow under a falling head as was discussed in Part 2 of this article, but would be so complicated by the interdependent rates in loss of head by all three tanks as to require a whole complex of partial integrations, which seem overly nice for the character of our data. Hence, as a "design convention," we will take as the effective head at each tank the elevation of its bottom point O, plus one-half the height of oil in the tank. This is conservative, with a margin to take care of friction losses through the various pipe fittings. From Fig. 1-b (see sheet 5), the gradient diagram for these conditions:

$H_x = L_o h_o + L_1 h_1 =$ (2) $(1/32050\ B_o^{1.81}) +$ (1) $(1/809\ B_1^{1.74} = 15$ ft.

I. $B_o^{1.81} = 240{,}375 - 19.8\ B_1^{1.74}$

$H_y = L_o h_o + L_2 h_2 + L_3 h_3 =$ (2) $(1/32050\ B_o^{1.81}) +$ (2) $(1/7190\ B_2^{1.78}) +$ (1) $(1/7190\ B_3^{1.78}) = 15$ ft.

II. $B_o^{1.81} = 240{,}375 - 4.46\ B_2^{1.78} - 2.23\ B_3^{1.78}$

$H_z = L_o h_o + L_2 h_2 + L_4 h_4 =$ (2) $(1/32050\ B_o^{1.81}) +$ (2) $(7190\ B_2^{1.78}) +$ (1.5) $(1/809\ B_4^{1.74}) = 21$ ft.

III. $B_o^{1.81} = 337{,}000 - 4.46\ B_2^{1.78} - 29.7\ B_4^{1.74}$

Subtracting II from III:

IV. $29.7\ B_4^{1.74} = 96{,}625 + 2.23\ B_3^{1.78}$.

These data are taken from the article entitled, "Simplified pipe line computations," by Peyton Bryan, in the January, 1947, issue of *The Petroleum Engineer*, pages 178 to 180, inclusive.

TABLE 1

Assumed value of B_o	$B_o^{1.81}$	$240{,}000 - B_o^{1.81} = 19.8\ B_1^{1.74}$	B_1	$B_o - B_1 = B_2$	$4.46\ B_2^{1.78}$	$240{,}400 - B_o^{1.81} - 4.46\ B_2^{1.78} = 2.23\ B_3^{1.78}$	B_3	$96{,}600 + 2.23\ B_3^{1.78} = 29.7\ B_4^{1.74}$	B_4
450	63,400	177,000	186	264	91,100	85,900	377		
550	91,200	149,200	169	381	175,000	−25,800	..		
500	76,800	163,600	178	322	129,500	34,100	224	130,200	123
505	78,100	162,300	177	328	134,100	28,200	202	124,300	121
504	77,900	162,500	177	327	132,300	30,200	206	126,800	121

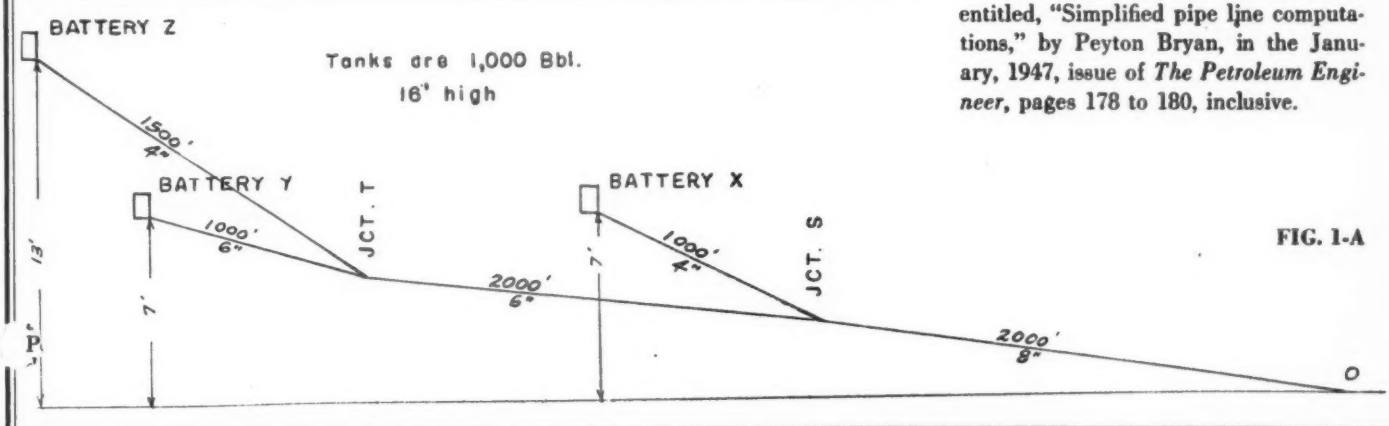
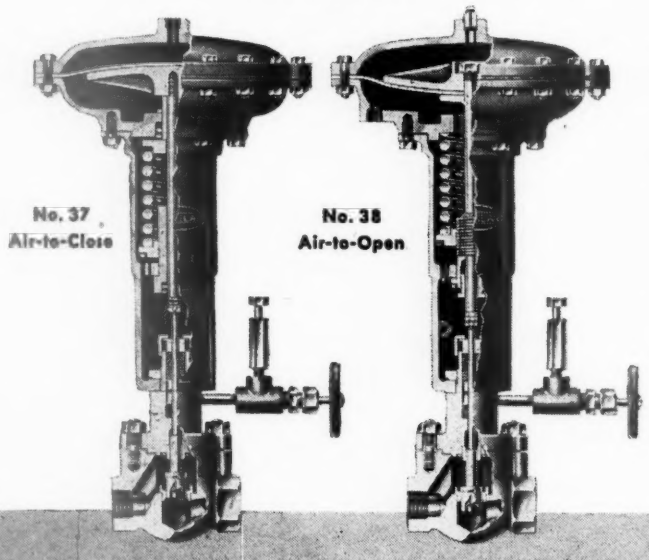


FIG. 1-A

The Interchangeable Plug and Seat Ring in Masoneilan Percentage Piston Control Valves Gives You

5 VALVES IN ONE

Percentage Pistons and Seat Rings



No. 37
Air-to-Close

No. 38
Air-to-Open

Because the trim size of Masoneilan Percentage Piston Valves is interchangeable, you can easily change any valve from one size to another by merely replacing the plug and seat ring. Since trim sizes are available in ¾", ½", ⅜", ¼", and ⅛", it means that you get 5 valves in one by simple conversion of the trim.

The flow range of orifice sizes of from ¾ to ⅛ inch represents a relative capacity ratio of 36 to 1. The capacities of the Percentage Piston Valves have been selected and spaced for the primary purpose of covering the desired range of flow with the minimum number of trim sizes.

In addition to interchangeable trim, these control valves give you the excellent flow characteristics of larger size valves even down to the ⅛" size. The orifice diameter has been held to a minimum to reduce the errosive effect of high velocity fluids. Forged steel globe type body provides unusually large capacity.

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EFFECT OF CRUDE GRAVITY ON PERFORMANCE OF GAS DRIVE RESERVOIRS

(This series of charts and data is taken from the exclusive article by Morris Muskat and M. O. Taylor, published in The Petroleum Engineer in December, 1946, pages 88-98, inclusive.)

In Fig 10. (sheet 4) are shown the pressure and gas-oil ratio histories of the reservoirs producing the different crude gravities, as functions of the cumulative oil recovery, expressed as a fraction of the pore space, i.e., by the equation:

Cumulative recovery =

$$\left(\frac{\rho_o}{\beta}\right)_i - \rho_o/\beta \quad \ldots\ldots \quad (3)$$

where $(\rho_o/\beta)_i$ is the initial stock tank oil saturation.

The curves of Fig 10 are all similar to those obtained previously for gas drive reservoirs, except for the curves I referring to a 10-deg. API gravity crude. For the latter the pressure and gas-oil ratio variation initially follows the same general trend as for the higher gravity crudes. After a cumulative recovery of 7.83 per cent of the pore space, however, the pressure drops almost vertically, and the gas-oil ratio rises almost vertically to a maximum far greater than that for any of the other crudes.

The ultimate recovery at 100 psia, the ultimate free gas saturation, and the maximum gas-oil ratio are plotted as functions of the API gravity of the crude in Fig. 11 (sheet 4). It will be noted that the ultimate free gas saturation, in per cent of the pore space, increases continuously with increasing API gravity. This, of course, is merely a reflection of the decreased oil viscosity with the high gravity crudes. The recovery as a fraction of the initial stock oil in place also increases continuously with increasing gravity, although a marked flattening of the curve develops at a gravity higher than 40-deg. API. This flattening is the result of the increasing role played by the oil shrinkage as the crude gravity is increased, and the associated tendency for a decrease in the absolute value of the recovery. This effect is strikingly shown in the curve for the recovery expressed as a fraction of the pore space, where it is seen that a maximum absolute recovery is reached at approximately 40-deg. API, with lesser recoveries for the higher and lower gravity crudes. This result, which appears anomalous at first glance, was indicated by the previously published calculations in which the shrinkage factor for the oil and gas solubility were increased simultaneously. Here the higher gravity crudes enjoy the advantages of both increased gas solubility and lower oil viscosity; however, the associated increase in shrinkage is still sufficient to counterbalance the favorable factors and lead ultimately to lower absolute recovery values. It is clear, therefore, that in the case of the high gravity crudes the oil shrinkage is the controlling factor determining the oil recovery. This also suggests that in such reservoirs pressure maintenance and prevention of oil shrinkage in the reservoir should be especially beneficial.

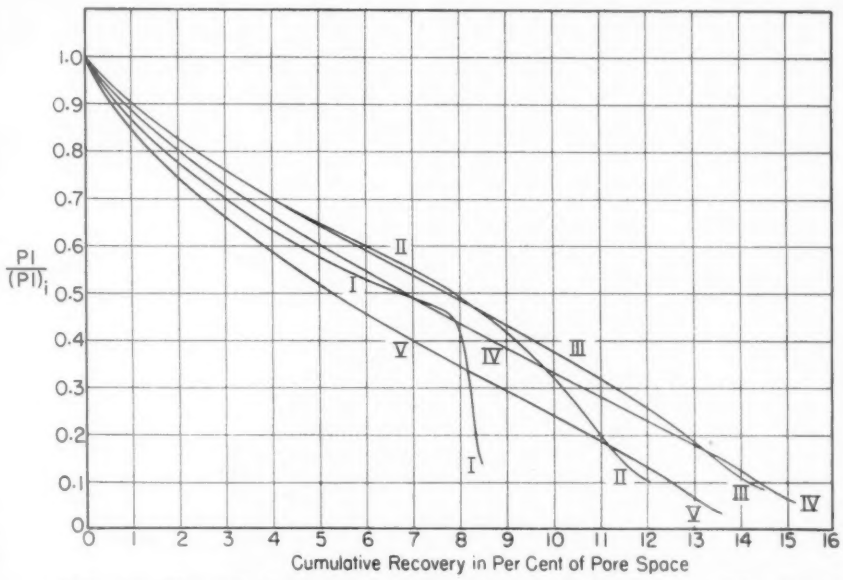

FIG. 12. The calculated productivity index variations in gas drive reservoirs producing different gravity crudes, as functions of the cumulative recovery.

$$\frac{\text{PI}}{(\text{PI})_i} = \frac{\text{Current Productivity Index}}{\text{Initial Productivity Index}}$$

Curves I: 10° API; Curves II: 20° API; Curves III: 30° API; Curves IV: 40° API; Curves V: 50° API.

The decreases in productivity index for the various reservoirs producing different crude gravities are plotted in Fig 12. To eliminate the uncertainties associated with theoretical calculations of the absolute productivity index, only the relative magnitudes—in the limit of vanishing pressure differential—as compared to the initial values, are plotted. These were calculated by means of the equation:

$$\frac{\text{PI}}{(\text{PI})_i} = \frac{(k_o/k)/\mu\beta}{\{(k_o/k)/\mu\beta\}_i} \quad \ldots\ldots \quad (4)$$

where k_o/k is the relative permeability of oil as a function of the oil saturation, as plotted in Fig. 9, and the subscript i indicates the initial value. It will be seen that in all cases the productivity index will ultimately fall to less than 15 per cent of its initial value. Moreover, the final value reached at 100 psia decreases continuously with increasing crude gravity. This relationship is evidently to be correlated with the decreasing residual oil saturation with increasing crude gravity, as implied by the gas saturation curve of Fig. 11. As the changes in viscosity and formation volume factors between 3000 and 100 psi are approximately the same for the different crudes the controlling term in equation (4) is k_o/k, which is determined by the residual oil or gas saturation.

It is to be emphasized that the above results are not to be used in estimating the recovery or determining the quantitative performance history of any particular gas drive reservoir. They have significance only with respect to the relative behavior of reservoirs having comparable rock characteristics and general structural features. It will be recalled that the calculations were all based on the assumption that the reservoirs are produced entirely by gas drive, without the aid of gravity drainage or water encroachment.

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Left above: The Model P Air-actuated Clutch is furnished in sizes from 14" to 36", with capacities from 65 to 990 hp.

Left: The Model EH Friction Clutch is furnished in single or two-plate assemblies, from 14" to 42", in capacities ranging from 65 to 875 hp.

METHODS OF COMPUTING FLOW OF OIL IN PIPE LINES

The trial values should be tabulated, somewhat as in Table 1, in order to follow the effects upon the variables of changes in the assumed values of the total flow rate B. The example was worked with a 10-in. log-log rule, which accounts for the rounding-off to three significant figures. The solution in Table 1 shows the total flow rate to be 504 bbl. per hr., made up of 177 bbl. per hr. from Battery X, 206 bbl. per hr. from Y, and 121 bbl. per hr. from Z (see sheet 4).

It has been the practice in some offices to calculate the flow rate of each individual battery, with nothing else "on the line," and to assume that the battery with the "best" gradient will be the only one flowing until it has been emptied, whereupon the second-best battery will come on the line, and so on. The seriousness of this fallacy, in causing the possibilities of gravity-systems to be overlooked, is illustrated in our example.

To solve for the flow rate of Battery X, alone, we need to convert the hydraulic gradient existing in the 4-in. line to an equivalent gradient in the 8-in. As the rate of flow through each of these lines obviously will be the same, we can equate their respective flow equations:

$$46.73\ h_4^{0.57} = 308.6\ h_8^{0.55}$$

$$\therefore\ h_4 = 27.5\ h_8^{0.96}$$

Referring to Fig. 1-b:

$$2\ h_8 + 27.5\ h_8^{0.96} = 15 \text{ ft.}$$

$$h_8 = 0.5 \text{ ft.}$$

$$B = 308.6\ h^{0.55}$$

$$= 211 \text{ bbl. per hr.}$$

Similarly, for Battery Y, it is found that the equivalent 8-in. gradient is 1.11 ft. per 1000 ft., and the rate of flow for Battery Y alone would be 326 bbl. per hr. Effecting the same substitutions for Battery Z, the flow rate for that battery alone is found to be 188 bbl. per hr. Now, if as a matter of practical operation it is required to run 1000 bbl. of oil from each battery in an 8-hr. day, it is apparent that pumps will be required for at least two of the batteries, for this method of calculation indicates that slightly more than 13 hr. are needed for gravity flow. Actually, the gravity rates are sufficiently high, when correctly computed, to deliver more than the required runs for an 8-hr. day.

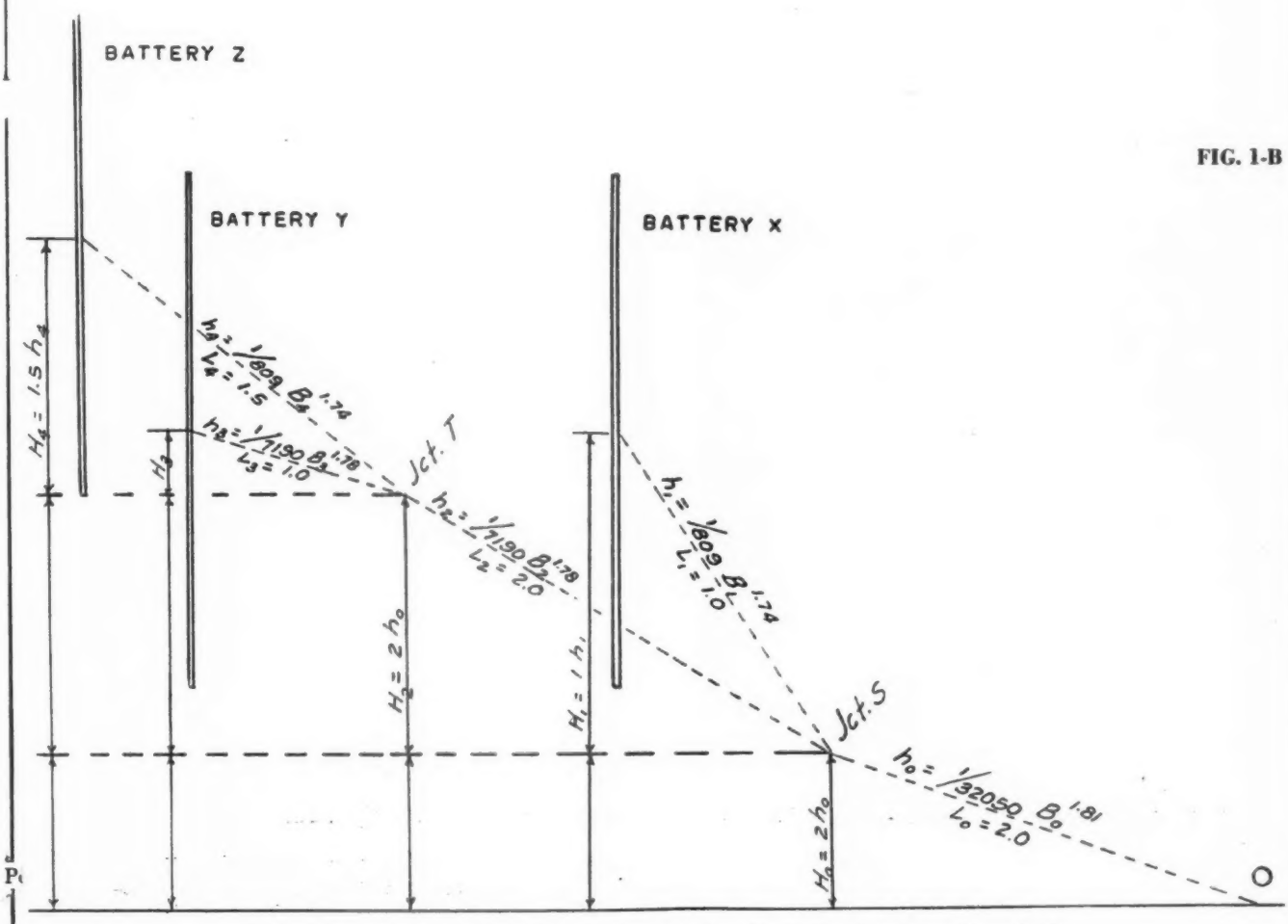

FIG. 1-B

These data are taken from the article "Simplified Pipe Line Computations," by Peyton Bryan in the January, 1947, issue of The Petroleum Engineer, pages 178 to 180, inclusive.

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• **Wayne C. Edmister,** formerly senior process engineer with Foster-Wheeler Corporation, is now senior chemical engineer with Delner Corporation, a subsidiary of Hydrocarbon Research, Inc. It is understood the firm was awarded the architect-engineering contract for the facilities at the Brookhaven National Laboratory, a regional research center in nuclear physics under the direction of the Atomic Energy Commission.

• **Peter P. Gregory,** consulting petroleum engineer of 1503 Fort Worth National Bank Building, Fort Worth, Texas, has been commissioned to make an examination of an oil concession in the Upper Magdalena Valley of the Republic of Colombia. He may also inspect some properties in Venezuela and Ecuador.

• **Barclay K. Read** has been named assistant sales manager of Shell Chemical Corporation's eastern division, it is announced by J. Oostermeyer, president. Read was formerly New York district sales manager of Shell Chemical. In his new position he will assist in directing the company's expanding marketing program throughout the East.

• Maximilian H. Leister, general manager of motor products sales and supervisor of advertising of Sun Oil Company, announces the appointment of **Laurens H. Fritz** as industrial advertising manager.

Fritz, formerly with Aitkin-Kynett Company, Philadelphia, takes charge of advertising, sales promotion, and marketing research for industrial products and Sun's wholesale and furnace oil departments. He succeeds **John C. Fairchild,** who has resigned.

• **Claude E. Donaldson,** traffic manager of Shell Oil Company, retired February 1. For 30 years he has directed the movement of Shell products and materials by rail, air, highway truck, and inland waterways. In directing the movement of oil and petroleum chemicals, he has been in a position to observe improvements in speed and service of railroads, wide development of highway trucking, expanded use of inland waterways, and growth of pipe lines. Looking to the future, Donaldson predicts expansion of existing forms of transportation rather than development of new methods.

C. E. Donaldson

W. H. Adams, Donaldson's associate for 24 years, has been named as Shell's new traffic manager.

• **B. E. Van Arnsdale,** Casper, Wyoming, has been promoted to the position of manager of the land department of General Petroleum Corporation's Rocky Mountain district, according to a announcement at the company's headquarters in Los Angeles. General Petroleum is the western affiliate of the Socony-Vacuum Oil Company.

• **Hubert Guyod,** well logging consultant of Houston, Texas, recently spoke before the Dallas Petroleum Engineers Club on "Interpretation of Electric Logs in Limestone."

• C. H. Zachry, president of Southern Union Gas Company, Dallas, Texas, announces that **Tom Corr,** Pecos, Texas, has been transferred from Pecos to Santa Fe, New Mexico, as district manager of the company's entire northwestern New Mexico district. He replaces **O. B. Peacore,** who resigned recently.

Corr, who has been in the employ of Southern Union 15½ years, has been district manager of Southern Union's West Texas district for the last eight years. The preceding seven years of his employment were spent in the State of New Mexico during which time, as construction superintendent, he laid the original gas line into Santa Fe, and later served as main line superintendent at Albuquerque.

Southern Union's properties under Corr's supervision include Albuquerque, Santa Fe,

Tom Corr

Sloan Paxton

Farmington, Belen, Bernalillo, Los Lunas, and Tesque, and field operations in San Juan and McKinley counties.

Sloan Paxton, Pecos, Texas, succeeds Corr as district manager of Southern Union's West Texas district, which is composed of Pecos, Monahans, McCamey, Wink, Crane, Pyote, Brastow, and Wickett. Paxton, a Southern Unionite for 11½ years, has served as assistant district manager of these West Texas properties for 4½ years.

• **H. A. Mason** has been promoted to the position of assistant to the manager of laboratories, General Petroleum Corporation, with headquarters in the home office of the company in Los Angeles. Mason, who will complete his thirtieth year with the company in May, recently has been superintendent of the laboratories at General Petroleum's Torrance refinery.

• **John B. Duckworth** has been made an assistant director of research of Standard Oil Company (Indiana). He has been a member of the research department since 1936, except for four years in military service with the power plant section of the Air Technical Service Command at Wright field, Dayton, Ohio. Duckworth received his bachelor of science degree in mechanical engineering from Purdue University and is a member of the Society of Automotive Engineers.

At Standard of Indiana's research laboratories at the Whiting, Indiana, refinery **F. S. Wood** has been promoted to the position of group leader in charge of the lubricants group of the engine laboratory, **E. L. Gregory** has become mechanical supervisor with the rank of group leader in the engine laboratory, and **Dr. J. C. Bailie** has been advanced to assistant chief chemist.

• **S. H. Harrison,** formerly manager of machinery electrification for the Westinghouse Electric Corporation, Pacific Coast district, has been appointed Pacific Coast manager of the corporation's industrial division, at San Francisco. Announcement of the appointment was made by Chas. A. Dostal, vice president.

S. H. Harrison

Harrison takes over the industrial division duties handled since 1928 by **G. B. Rosenblatt,** who has also headed the marine division for the last six years. Rosenblatt is relinquishing his managerial duties to devote full time to serving personally the needs of major Westinghouse industrial and marine accounts throughout the district.

• **Clarence R. Abitz** has been appointed general manager of the McKees Rocks Works of the American-Fort Pitt Spring Division of the H. K. Porter Company, Inc., it is announced by C. R. Dobson, vice president in charge of operations. Abitz has long been associated with the H. K. Porter Company, Inc., and for several years was general manager of the 49th Street plant in Pittsburgh.

• **Frank W. Warner, Jr.,** engineering manager of the General Electric plastics divisions for the last three years, has been named engineering policy manager of the company's chemical department, according to announcement made by **Dr. Zay Jeffries,** G-E vice president and general manager of the department. Warner will be responsible for the co-ordination of all engineering and laboratory activities of the department and will have his headquarters at Pittsfield, Massachusetts.

• **B. E. Parsons,** for many years vice president and director of production of the General Petroleum Corporation, retired as of January 1, and **Max S. App,** who has been manager of the production department, succeeds him.

Max S. App

"Ben" Parsons, a Stanford graduate of the class 1910, spent the first two years of his business life as an assistant geologist for the Southern Pacific Company, and went with General Petroleum in 1914 as a geologist. In 1918 he became superintendent of the company's operations at Taft, and since then has worked on through the department up to the position from which he has just retired.

App has been with General Petroleum since April, 1912, when he went to work as an engineer at Taft. Since then he has enjoyed a well-merited and steady progress through the ranks of the production department and his excellent record of achievement explains his promotion to his new position. He has contributed to API and other industry activities, and is also a member of the Petroleum Production Pioneers.

SIX

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• **Arthur G. Gustafson** has been made manager of the construction division of the General Electric chemical department, it is announced by Dr. Zay Jefferies, company vice president and general manager of the chemical department. Gustafson's headquarters will be in Pittsfield, Massachusetts.

Gustafson has been with General Electric since 1929 when it purchased the Meriden plant. He served as superintendent at Meriden from 1929 to 1932 and was then put in charge of engineering at Pittsfield. In 1936 he was made manager of the Meriden Works and assumed additional responsibilities as manager of the Taunton Works when that plant was organized in 1941. He returned to Pittsfield in March, 1942, to assume new duties as manufacturing manager of the plastics division. In July, 1945, he was named manager of the construction division.

• **Col. G. deFreest Larner** has been elected a director of the H. K. Porter Company, Inc., it is announced by T. M. Evans, president. Colonel Larner has been assistant to the president for several years, supervising operations and coordinating activities of the many recent acquisitions to the Porter organization. He has recently returned from the Hinderliter Tool Company, manufacturers of oil field equipment at Tulsa, Oklahoma.

• W. W. Banks, president, Dallas Tank Company, Inc., Dallas, Texas, announces the appointment of **Malcolm V. Reed** to the office of assistant to the president. Prior to joining the Dallas Tank Company, Reed had been head of the engineering and planning department of the Wyatt Metal and Boiler Works, Houston and Dallas, for 15 years. Reed's new duties will be of a general administrative type.

M. V. Reed

• **Marshall Taylor, II,** petroleum engineer for Magnolia Petroleum Company at Alice, Texas, has recently been promoted to district petroleum engineer of the Alice district. **C. W. Kelly, Jr.,** district petroleum engineer at Alice, for the Magnolia Petroleum Company, has been transferred to the same position at Vanderbilt, Texas. He replaces **Roland Clark** who resigned to accept a position with the Asiatic Petroleum Company in Venezuela. **Orville Van Meter,** petroleum engineer at Brownfield, Texas, has been attached to the West Texas division's petroleum engineering office at Midland where he will specialize in reservoir engineering work. **Hubert Walker** has been employed by Magnolia as a petroleum engineer in the Chase district, Kansas.

• **Robert M. Hess** was recently promoted to the position of exploitation engineer for the East Texas Division of Shell Oil Company, Inc., at Kilgore, Texas.

• **Leonard E. Matzner** has been appointed advertising manager for Mack Manufacturing Corporation. Matzner had been serving the company in the capacity of assistant advertising manager since his return from active duty in the Pacific Theater.

• **Campbell M. Hunter,** O. B. E., an original partner of the firm Thompson and Hunter, died December 23 in London. For his extraordinary services during the first World War, he was decorated with the order of the British Empire. He was one of the foremost British oil technologists and with A. Beeby Thompson, O. B. E., who is still active in his own business, Hunter was a pioneer in the oil fields of Russia, Peru, Argentine, Burma, and Canada. At the time of his death he was president of the Hunter Valley Oil Company, Ltd., of Canada and president of the Dallas Dome, Wyoming, oil fields. He leaves a widow. His business as consultant is being carried on by F. A. Heaton in London.

• **J. H. Winters** has been promoted to eastern divisional manager of the Airtemp Division, Chrysler Corporation, according to H. A. Malcom, vice president and general sales manager. Winters will have charge of the Boston, Syracuse, New York, Philadelphia, and Washington regions.

Winters joined the Airtemp Division in April, 1945, as a district representative in the Dayton region. In September, 1945, he was appointed district coordinator of the Kansas City region. Later, he was named a staff assistant to the vice president and general sales manager.

J. H. Winters

• **Roe A. Gray** has been appointed a training coordinator for the Socony-Vacuum Oil Company in Venezuela. He recently was released from the armed services with a rank of lieutenant colonel and formerly was associated with the General Petroleum Corporation.

• **Robert P. Russell,** president of Standard Oil Development Company, has been awarded the Cadman memorial medal for outstanding research in petroleum science, the Institute of Petroleum has announced from London, England. The Cadman medal is awarded at least once every three years for scientific contributions in the field of petroleum. Russell will receive the medal June 4 when he delivers the second Cadman memorial lecture in the lecture hall of the Royal Institute, London.

As head of the central technical and research organization of Standard Oil Company (New Jersey), Russell guides the work of 2000 chemists, engineers, and technologists, who, operating as a team, have made major contributions to the development of new processes and new and improved petroleum products.

• **Earle H. Clark** of Breckenridge, Texas, has been appointed membership secretary of the Texas Mid-Continent Oil and Gas Association, it has been announced by Charles E. Simons, vice president and general manager.

Earle H. Clark

Clark, former special agent for the Federal Bureau of Investigation and ex-football star at Texas Christian University, worked his way through college as a roustabout in the West Texas oil fields. Born in Oklahoma City, he was reared in Breckenridge, where his brother, Lester Clark, is an oil operator. Clark succeeds the late W. H. Pullman as head of the Texas Mid-Continent's membership activities.

• **Dr. John W. Frey** and **Franklin G. Wilson** have recently been added to the staff of the American Petroleum Institute. Dr. Frey is director of the Institute's division of marketing and Wilson is assistant

John W. Frey

F. G. Wilson

director, department of safety. Both are making their headquarters temporarily in the Washington, D. C., headquarters of the Institute.

Dr. Frey was engaged in research work for the U. S. Bureau of Mines in 1928, and since that time has held various positions in the government service. During the recent war he was director of marketing for PAW and later special assistant to the deputy director.

Wilson was with the Gulf Oil Corporation at its Port Arthur refinery and in the engineering department of Gulf at Pittsburgh. During the war he served in a number of important capacities with PAW, after which he joined the Cities Service Oil Company at Lake Charles, Louisiana, as chief draftsman.

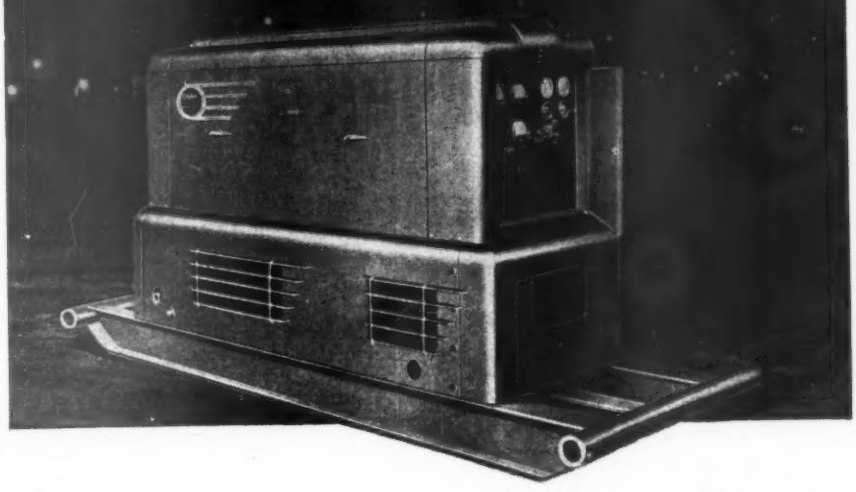
• **Russell B. Weston** has been promoted to the post of advertising manager by the Ethyl Corporation. Weston, who has been assistant advertising manager, joined Ethyl nearly 20 years ago as a field representative in the New York division and has served in several capacities covering almost every phase of sales department activities, including the duties of sales promotion manager. A native of Buffalo, New York, he is a graduate of Union College in Schenectady, New York.

• **Harry N. Stamper,** construction engineer for Humble Oil and Refining Company's production department in Houston, Texas, has been appointed assistant chief civil engineer in that department. Stamper joined Humble in 1927 as a civil engineer, and in 1934 was appointed division civil engineer of the West Texas division of the production department, with headquarters in Midland. In 1937 he was transferred to Houston as construction engineer. During his career with Humble, Stamper has been engaged in the development of construction methods and designs for the production department and has been directly in charge of construction of numerous gasoline and compressor plants.

Another change in the production department's supervisory forces was the transfer of **F. K. Sawyer,** assistant gas plant chief clerk for the Katy gas cycling plant at Katy, Texas, to the Pledger natural gas system at Danciger, Texas, as district chief clerk.

• **Frederick C. Abbott** has been appointed manager of labor and personnel relations for the Pennsylvania Salt Manufacturing Company, it is announced by Y. F. Hardcastle, vice president in charge of manufacturing. Before his new appointment, Abbott was assistant production manager. Previously, he was manager of the new products division. He joined Pennsalt in 1943, from the Ozark Chemical Company.

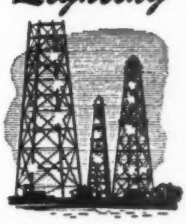
Designed and Built for Oil Field Jobs . . .



Onan Electric Plants are built tough and rugged, to stand up under the severe operating conditions of the oil fields. Powered by heavy-duty Onan Engines, they give dependable, continuous, full capacity service with a minimum of maintenance.

Onan single-unit construction, with engine and generator direct-connected, assures permanent alignment, gives these plants unusual compactness, and greater efficiency. Offered in a wide range of sizes and models, they meet the needs of such applications as geophysical survey; lease-house and rig-lighting; operating pumps, shale-shakers, bug fans and power tools.

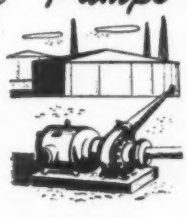
Lighting



Survey

Power Tools

Pumps

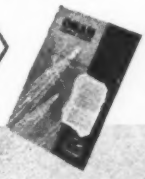


A MODEL AND SIZE FOR EVERY APPLICATION

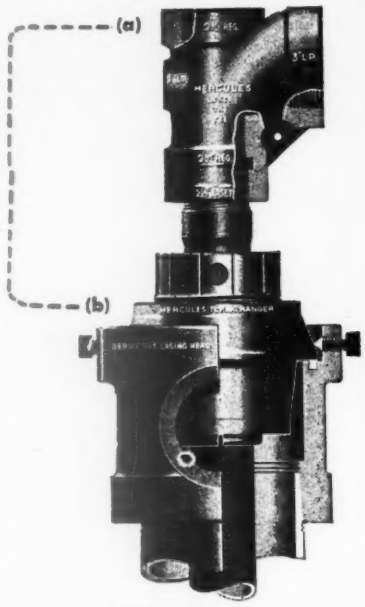
ALTERNATING CURRENT: 350 to 35,000 watts in all standard voltages and frequencies. DIRECT CURRENT: 600 to 10,000 watts, 115 and 230 volts. BATTERY CHARGERS: 500 to 3,500 watts; 6, 12, 24 and 32 volts.

D. W. ONAN & SONS INC.
2752 ROYALSTON AVE.
MINNEAPOLIS 5, MINN.

Write for special folder



Onan PRODUCTS **ELECTRIC PLANTS**



FULLY PATENTED

WHAT A DIFFERENCE...

HERCULES PUMPING WELL HOOK-UP MAKES!

Note how the Hanger sits down in the casing head out of the way; the compactness of the entire hook-up . . . reducing the number of connections necessary in connecting a well the old way.

(a) Hercules Pumping and Flowing Tee is the original and only Tee with a combination Plain and EUE thread. (Supplied in any combination.) Heavier and stronger than an ordinary Tee.

(b) Hercules Forged Steel Tubing Hanger—with Forged Steel Slips on which tubing hangs—affords absolute tubing protection. Has the FAMOUS Hercules Packing above slips with threaded nut to distort packing, independent of tubing weight. (Fits any Berry Pattern Casing Head.)

Sold at all supply stores

HERCULES TOOL COMPANY

TULSA, OKLAHOMA, Box 286

EXPORT OFFICE: 30 Rockefeller Plaza
NEW YORK, U.S.A.
CABLE ADDRESS: HERTOCO

CRUDE, CRACKED AND VOLATILE

A visitor to an asylum asked an inmate his name.

"George Washington."

"But the last time I was here, you were Abraham Lincoln," the visitor said.

"That," said the man sadly, "was by my first wife."

* * *

Betty: You slapped that cute chiropodist. Why?

Lucy: The fresh thing! When he worked on my corns, he started feeling his oats!

* * *

"I love you—OUCH!"
"I love you—OUCH!"
And there you have the story of two porcupines necking.

* * *

"I can't quite diagnose your case," said the doctor. "I think it's drink."

"All right, doctor," the patient gravely replied, "I'll come back when you're sober."

* * *

The Queen Bee is a hardy soul—
She thumbs her nose at birth control;
Which is the reason beyond a doubt,
There's so many sons of bees about.

* * *

Personnel man: Do you go with the girls?
Applicant: No, sir.
P. M.: Do you mean to tell me you do not go with girls?
A: Yes, sir.
P. M.: Why not?
A.: My wife won't let me.

* * *

A married couple were sleeping peacefully when the wife suddenly shouted out in her sleep: "Good Lord! My husband!"

She was awakened by the crash of glass as her husband waked with a start and jumped out the window.

* * *

"Look, sailor, how long is this car going to keep stalling like this?"

"Just as long as you do, Baby."

* * *

Mother: Katie, get off that sailor's lap!
Katie: But, Mother, I was here first.

* * *

"Must you drive with one hand?" inquired the pretty passenger.

"Sure. The car won't steer itself," replied her boy-friend.

* * *

The absent-minded professor walked into the village barber shop, sat down in the chair and requested a haircut. "Certainly, sir," said the barber. "Would you mind taking off your hat?"

The professor hurriedly complied. "I'm sorry," he apologized. "I didn't know there were ladies present."

* * *

A negro cook went into a bank with a check from the woman for whom she worked. As Mandy, the cook, could not write, she always endorsed her checks with a big "X." But on this occasion she made a circle on the back of the check.

Bank Teller: What's the big idea, Mandy? Why didn't you make a cross, as usual?

Mandy: I done got married yestiddy and I'se changed mah name.

"Hey," cried Satan to the new arrival. "You act as if you owned the place!"

"I do," came the reply. "My wife gave it to me before I came."

* * *

Alimony is a system by which, when two people make a mistake, one of them continues to pay for it.

* * *

Chemical Warfare—The eternal fight between blondes and brunettes.

* * *

Then there was the hillbilly who put a silencer on his shotgun because his daughter wanted a quiet wedding.

* * *

Here's a new type of arithmetic:

Two little negro boys were loitering on a street corner, when one said to the other:

"How old is you?"

"Ah's five," was the reply. "How old is you?"

"Ah don't know," said the first boy.

"You don't know how old you is?"

"Nope."

"Does women botha you?"

"Nope."

"Youse fo'."

* * *

"You call that a race horse? Can the nag really run?"

"Run? Why, that horse can stand still faster than most horses can gallop."

* * *

After a terrific struggle the law student finished his examination paper and then at the end wrote:

"Dear Professor: If you sell any of my answers to the funny papers, I'll expect you to split 50-50 with me."

* * *

"Hello, coach!"

"I thought you were told not to drink while in training."

"What makes you think I've been drinking, coach?"

"I'm not the coach!"

* * *

Mechanics professor: James, name a great time-saver.

James: Love at first sight.

* * *

The men were climbing a telephone pole to repair a cable. A woman driving in her automobile saw them and remarked to her companion: "Look at those nitwits. From the way they're acting, you'd think I'd never driven a car before."

* * *

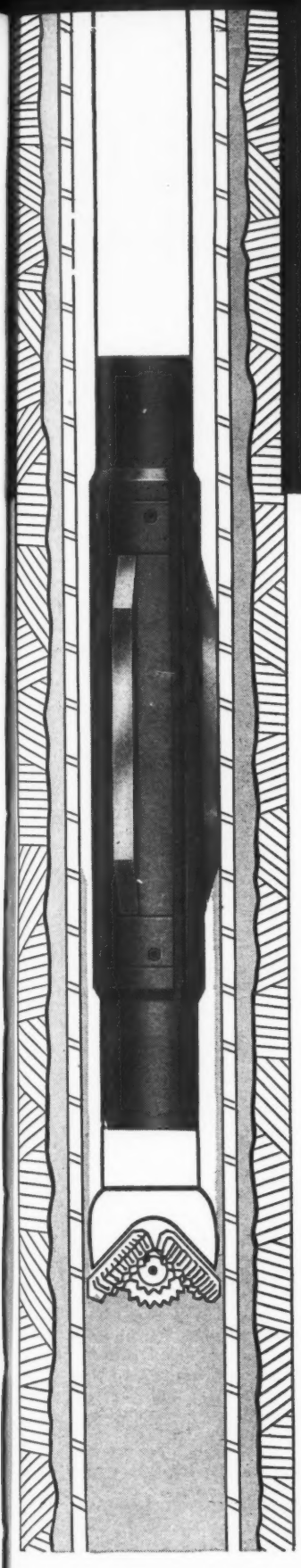
They tell of the two ambitous little fleas who worked hard and saved their money and finally went out and bought their own dog.

* * *

A colored porter in a hotel was asked why rich men usually gave smaller tips than poor men. "Well, suh," the porter answered, "the rich man don't want nobody t' know he's rich and the po' man don't want nobody t' know he's po'."

* * *

"I'm going to have our marriage annulled." "How come?" "I just found out your father didn't have a license to carry a gun."

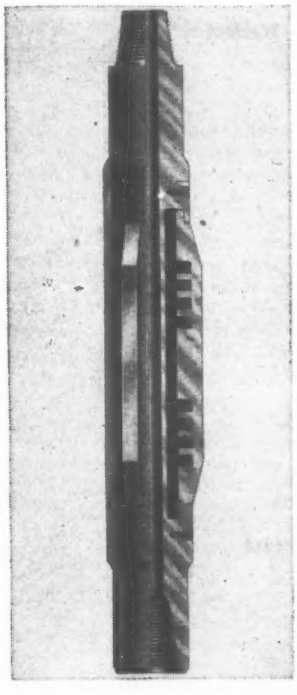


UNLESS the inside of your casing—the working surface—is smooth and clean, there is always a hazard of encountering difficulties in future down-hole operations. The use of a Baker Casing Scraper eliminates this hazard, for it effectively removes all obstructions from the inside of the casing, leaving it smooth and clean to its full I.D.

The time to do a scraping job on your casing is while the equipment still is up and the crew still on hand. It's then a simple matter to include a Baker Casing Scraper in the string as a "follow-up" behind the bit when running-in to drill out cement. Thus, in one operation, it is possible to remove the hardened cement, scale, sharp burrs from gun-shot holes, or other obstructions which might later damage packers, swabs and similar tools.

Why you should be using the BAKER ROTARY CASING SCRAPER

(Product No. 620)



EASILY USED BY YOUR CREWS—Simply include Casing Scraper in the string when the bit is run to drill out cement.

MAKE SURE CASING IS CLEAN AND SMOOTH—While the equipment is still up, and the crew on hand, scrape casing to leave it in perfect condition for future operations.

MAKES FUTURE WORK SAFE AND EASY—Leaves casing its full I.D., free from hardened cement or other obstructions which damage packers, swabs, bailers, or other tools.

REMOVES SHARP BURRS FROM GUN-SHOT HOLES—The Baker Casing Scraper is strong enough to cut away all such obstructions which interfere with subsequent operations.

MAY COST A LOT NOT TO RUN IT—Damage to packers or swabs, plus delays and re-running expense can easily cost a lot more than the reasonable rental.

LOW-COST RENTAL—Serviceman is not required, and the rental price is reasonable.

It is not necessary to worry about maintaining exact hydraulic pressure to expand the blades of a Baker Casing Scraper. Simply use all the springs behind all blades when you want to remove burrs from gun-shot holes, and similar "hard" scraping; use only part of the springs when you have paraffin and similar soft substances to scrape away. Blade pressure is then automatically controlled—all you need to do is "turn to the right."

BAKER OIL TOOLS

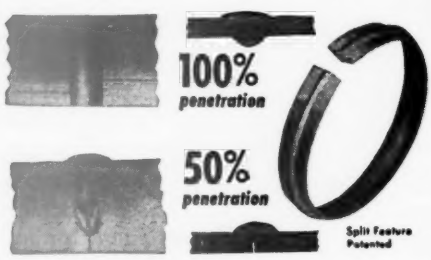
BAKER OIL TOOLS, INC., LOS ANG[illegible]

REFINERY LINES *and* PIPE LINES *can be Welded* BETTER *and* CHEAPER

by using . . .

WEDGE *Split* CHILL RINGS

Joints welded this NEW and BETTER way are STRONGER than the pipe itself. WEDGE Chill Rings with the patented SPLIT Feature strongly reinforce every joint. FLEXIBLE . . . an exclusive feature that makes each ring fit snugly inside the pipe. You get 100% penetration at every weld,



and the welds are made more easily and more rapidly. Finished welds are so strong that in case of shock or strain the pipe will fail before the reinforced joints. The use of WEDGE Split Chill Rings saves money, not only because the welding job goes faster, but because they permit use of LIGHTER pipe. It will pay you to investigate this NEW and BETTER way of welding refinery lines and pipe lines.

Write for Information

WEDGE PROTECTORS, INC.

3977 Jennings Road, Cleveland 9, Ohio

WEDGE *Split* CHILL RINGS SAVE MONEY

Annual sales meeting Lufkin Foundry

The annual sales meeting of the Lufkin Foundry and Machine Company was held January 16-18 in Lufkin, Texas. Discussing the progress made the past year, and formulating plans for the coming year were those shown in the accompanying picture. Foreground, W. W. Trout, vice president and general manager.

First row, left to right: A. V. Simonson, New York City; W. C. Trout, president; Charles Dyer, El Dorado, Arkansas; Guy Croom, plant superintendent, Lufkin; Cooper Richards, Great Bend, Kansas.

Second row: Bill Miner, Houston, Texas; Linvelle Caraway, Great Bend; W. T. Crowder, Kilgore, Texas; Elvin Read, Odessa, Texas; Taylor Hood, manager, engine department, Lufkin; and Robert Thompson, of Wichita Falls, Texas.

Third row: D. A. Reid, Tulsa, Oklahoma; Robert Lang, foundry superintendent, Lufkin; Ed Terrell, Dallas; Bob Miller, engine department, Lufkin; A. E. Caraway, Kilgore.

Last row (including men standing on sides): M. B. Harrison, Corpus Christi, Texas; E. P. Trout, vice president; Vernon Glenn, engine department, Lufkin; Newell Lynch, Seminole, Oklahoma; D. K. Womack, Odessa; Glenn Henderson, Los Angeles, California; E. H. Bounds, treasurer; and J. B. Hopper, chief engineer, Lufkin.

Not shown here but attending the conference was L. A. Little, vice president and district manager, Dallas.

Ladish changes named

In a move intended to better reflect the expanded scope of the company's activities, Ladish Drop Forge Company of Cudahy, Wisconsin, for more than 40 years one of the largest producers of steel and alloy forgings for industry, has announced that the corporate name has been change to Ladish Company.

It has been felt for some time that the inclusion of the specialized term "drop forge" in the company name may have implied a limitation of products to many industries and business people, particularly users of one of the Ladish major product lines, namely, forged and seamless welding pipe fittings.

A general announcement of the new name will be made by full page ads in early issues of leading business publications, emphasizing that no change has been made in either the company's organization or policies.

Visit Failing plant

A group of Englishmen, headed by Sir William Stampe of New Delhi, India, made a visit to the factory of the George E. Failing Supply Company of Enid, Oklahoma, recently for the purpose of inspecting the manufacture and operation of Failing portable drilling equipment. In the party with Sir William were A. S. Wade of Washington, D. C., member of the English Supply Mission; E. M. Fones of the Mitchell Engineering Company of London; and John B. Weil, Failing agency representative in Johannesburg, South Africa. They were accompanied by G. P. Gregory, Jr., New York City, Failing export manager.

The Failing company delivered several portable drills to the English government last year for use in India and the recent visit of the group was for the purpose of inspecting additional equipment.

Heads Texaco Development

William M. Stratford has been elected president of Texaco Development Corporation, it is announced. He succeeds R. J. Dearborn, who has been retired after 27 years with The Texas Company and the Texaco Development Corporation.

William P. Gee and Charles F. Teichmann have been elected vice presidents of Texaco Development Corporation.

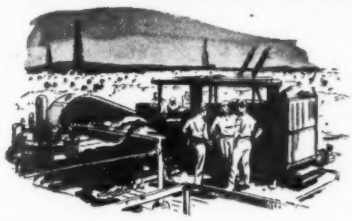
Stratford was employed by The Texas Company in 1919 as a chemist in the company's research laboratory at Port Arthur, Texas. He was later transferred to the New York offices as patent attorney and in 1933 was elected vice president and a director of Texaco Development Corporation. Gee and Teichmann also started with Texaco as chemists at Port Arthur. Gee's connection with Texaco Development began in 1934 when a program of licensing the corporation's processes for manufacturing lubricating oils was begun. This program resulted in the widespread use of these processes throughout the oil industry. Teichmann was a patent attorney for The Texas Company for several years before joining Texaco Development Corporation.

Moves office location

The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, announces that its Los Angeles office has moved from the Banks Huntley Building on South Spring Street to the Petroleum Building, Rooms 750 and 751, 714 West Olympic Boulevard. The telephone is Richmond 7-3849 and 3850.

Superior 6G-510

GAS DRILLING ENGINE



Specifically designed and built for drilling service this engine has created many outstanding performance records since its introduction into the oil country in 1945.

BRIEF SPECIFICATIONS

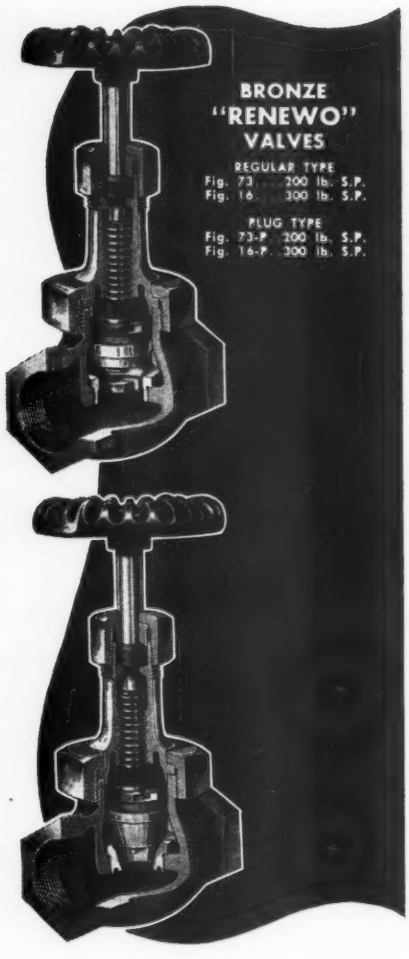
Number of Cylinders	6	Length, Overall	141⅛″
Bore and Stroke	8½″ x 9″	Width, Overall	65⅞″
R.P.M.	900	Height, Overall	91½″
Rated H.P. (continuous service)	300	Net Weight—Approximate, lbs.	12,750
Main Bearings: Type	Precision		
Number	7		
Diameter	5″		

For additional performance information and complete specifications, send for our Bulletin No. 315.

First in Quality — THE NATIONAL SUPPLY COMPANY — NATIONAL BLUE PRODUCTS

THE NATIONAL SUPPLY COMPANY

GENERAL SALES OFFICES: TOLEDO, OHIO • DIVISION OFFICES: DENVER • FT. WORTH
PITTSBURGH • TULSA • TORRANCE • EXPORT: NATIONAL SUPPLY EXPORT CORPORATION,
30 ROCKEFELLER PLAZA, NEW YORK, N.Y., U.S.A. • RIVER PLATE HOUSE, 12 SOUTH PLACE, LONDON, E. C. 2



Here's all you need...

to convert a regular type into a plug type valve...

SEATS AND DISCS INTERCHANGEABLE ★

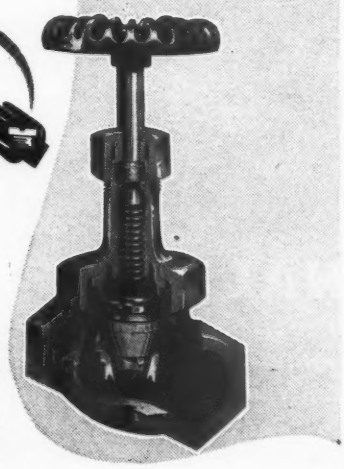
Just insert a plug type seat and disc in place of the regular type, and you change an *entire* Bronze "Renewo" Valve from regular to plug type—providing all the extra advantages of this type, including its ability to stand up under hard service. No other change is necessary. The plug type seat-and-disc combination is made to *fit perfectly* into a regular type valve of corresponding size and pattern. And you have this same interchangeability in Iron Body "Ferrenewo" Valves. You don't have to buy an entire new valve . . . you don't even have to take the valve out of the line.

*Lunkenheimer interchangeability goes still farther. *All parts* of 200 lb. "Renewo" and 150 lb. "Ferrenewo" Valves (except bodies and bonnet rings) are quickly, easily, perfectly interchangeable. Fewer parts are needed; ordering and handling are simplified; repairs are facilitated. You save time, labor, money.

Write for a copy of Circular 567—

LET YOUR LUNKENHEIMER DISTRIBUTOR DEMONSTRATE . .

Your nearby Lunkenheimer Distributor will welcome the opportunity to show you actual samples and demonstrate the interchangeability of parts in "RENEWO" and "FERRENEWO" Valves. You'll find it a big factor in increasing efficiency, lowering costs.



THE LUNKENHEIMER COMPANY

CINCINNATI 14, OHIO, U. S. A.

NEW YORK 13, CHICAGO 6, BOSTON 10, PHILADELPHIA 7.

EXPORT DEPARTMENT: 319-323 HUDSON ST., NEW YORK 13, N. Y.

Out of retirement

The Continental Supply Company, Dallas, Texas, has announced the appointment of Frederick L. Convers as vice president in charge of the New York office and foreign operation.

Convers formerly served Continental in the same capacity, having retired in June, 1945. At that time, he was succeeded by

C. J. DeLay

F. L. Convers

R. M. Dinges. It was upon the death of the latter that Convers resumed his old position.

Manager of Continental's export division is Charles J. DeLay. DeLay has held this position since June, 1945, having been with the company since 1919, his first point of service being Wichita Falls, Texas.

Chapple promoted

Appointment of Bennett S. Chapple, Jr., as assistant vice president—sales, United States Steel Corporation of Delaware, is announced by David F. Austin, vice president.

After his graduation from Antioch college in 1927, Chapple served in various capacities with the American Rolling Mill Company until 1936, when he joined the sales department of Carnegie-Illinois Steel Corporation as manager of sales promotion. He subsequently served as assistant to vice president in charge of emergency defense coordination and as assistant manager of sales, New York district sales office of Carnegie-Illinois.

In 1944 Chapple resigned to become assistant to the president of the Firth Sterling Steel Company. In 1945 he joined the staff of the vice president in charge of sales, United States Steel Corporation of Delaware.

Joins Tube Turns

Donald A. MacNeil has joined the sales staff of the forging division of Tube Turns, (Inc.), Louisville, Kentucky, it is announced by John G. Seiler, the firm's vice president and general sales manager. He will make his headquarters in Chicago, in the Utilities Building, 327 South LaSalle Street.

D. A. MacNeil

MacNeil was associated with the Kelly Steel Works, Inc., Chicago, for 16 years before resigning the vice presidency of that organization to join Tube Turns (Inc.). A native Chicagoan, he attended the University of Chicago and is one of the best known and most highly respected executives in the industrial forgings field.

To research staff

Young Radiator Company, Racine, Wisconsin, has announced the addition of Ralph Rayner to its research department. Rayner was born in Racine, graduated from the Waukegan, Illinois, High School, and from the University of Illinois as a mechanical engineer in 1943. During the war he served as an engineering officer on an L. C. I. in the Pacific. Formerly employed by a truck manufacturer, Rayner was a design engineer and worked with castings and forgings.

Ralph Rayner

At Young Radiator Company he will be employed as a mechanical engineer in the research department and will assist in the various research problems of the heat transfer products manufacturer.

John Tancred dies

John Tancred, Jr., sales promotion manager, Jarecki Manufacturing Company, Houston,Texas, died recently in a Clarendon, Texas, hospital from injuries received in an automobile accident near that city.

John Tancred, Jr.

Tancred was born in Thurber, Texas, December 6, 1901, and lived his early life in Wichita Falls, Texas, later moving to Dallas, Texas, where he resided until his entrance into the United States Army Air Force in 1942. He served in three South Pacific invasions and was discharged in January, 1946, with the rank of major.

Business merger

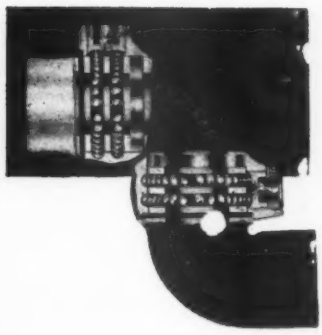
The business and affairs of the Catalytic Construction Company and the Catalytic Engineering and Construction Company are now being conducted by the Catalytic Construction Company, to avoid duplication in accounting. Both companies were merged according to law as of December 31, 1946. The address of the Catalytic Construction Company is 1600 Walnut Street, Philadelphia 3, Pennsylvania.

Kobe district manager

The appointment of Ralph Fanthus to the post of Valley district manager has been announced by Kobe Incorporated. Fanthus has been associated with the development and installation of Kobe pumps and the design of hydraulic pumping systems since 1933. He brings to his new post a rich experience in the handling of production problems and the adaptation of Kobe pumping systems to field conditions. He will be in charge of Kobe activities in the San Joaquin Valley, making his headquarters in the Haberfelde Building in Bakersfield, and will continue under the direction of R. J. Lyons, division manager in Huntington Park, California.

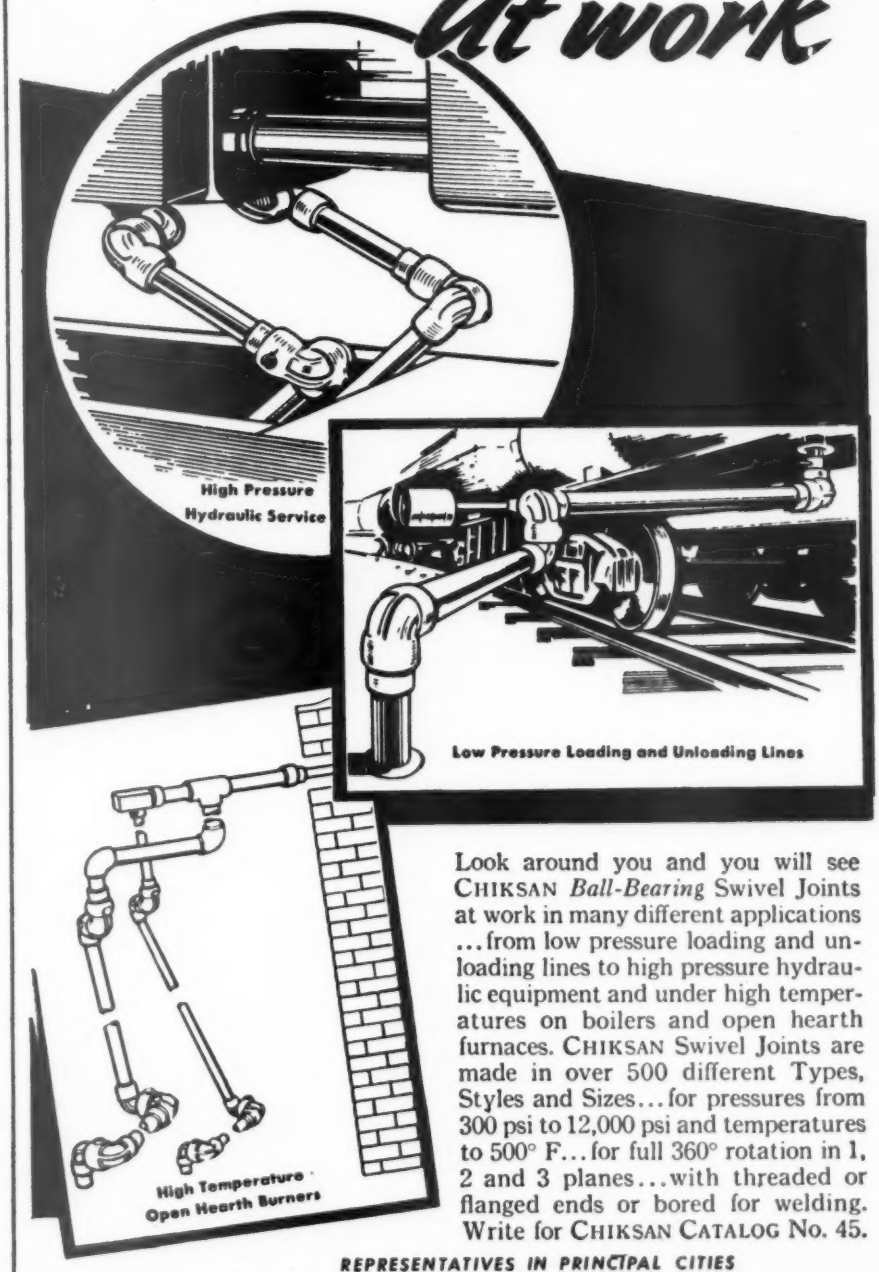
Ralph Fanthus

CHIKSAN



BALL BEARING SWIVEL JOINTS

At work.



Look around you and you will see CHIKSAN *Ball-Bearing* Swivel Joints at work in many different applications ...from low pressure loading and unloading lines to high pressure hydraulic equipment and under high temperatures on boilers and open hearth furnaces. CHIKSAN Swivel Joints are made in over 500 different Types, Styles and Sizes...for pressures from 300 psi to 12,000 psi and temperatures to 500° F...for full 360° rotation in 1, 2 and 3 planes...with threaded or flanged ends or bored for welding. Write for CHIKSAN CATALOG No. 45.

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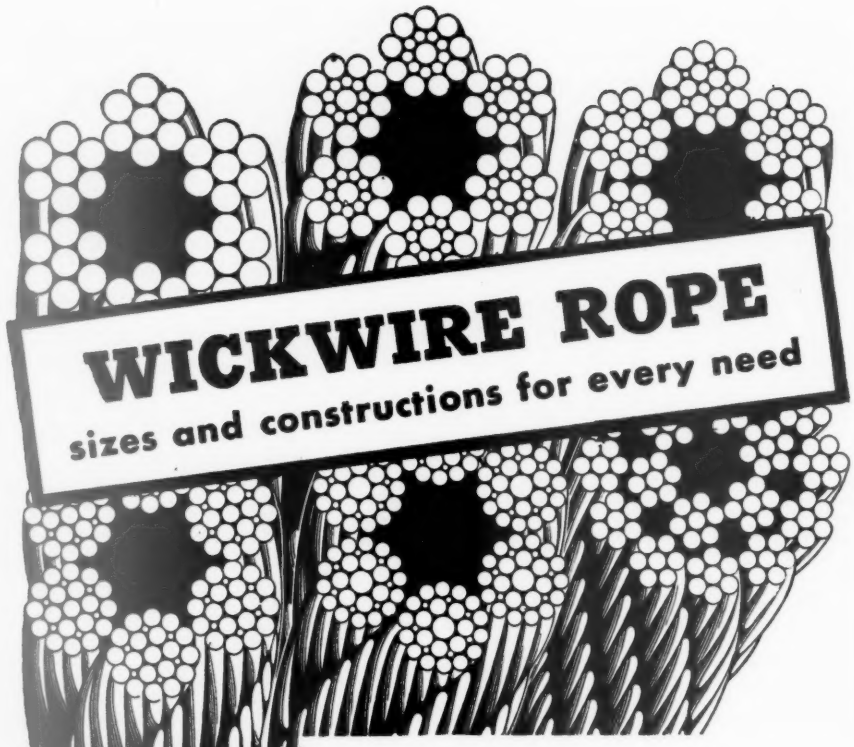
BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES

CHIKSAN COMPANY

BREA, CALIFORNIA

New York 7 Houston 2



Specific tasks call for specific types of wire rope . . . but, regardless of construction, it must be tough and dependable.

That's why more and more men are relying on the stout steel muscles of Wickwire Rope.

Back of the durability and dependable performance of Wickwire Rope lies 126 years of specialization in the manufacture of wire and wire products. Every step—from ore to finished product—is handled in our own plants. Only the sound heart of the steel ingot is used for Wickwire Rope and every wire is drawn until it is accurate within a fraction of a thousandth of an inch.

Wickwire Rope is available in all sizes and constructions, both regular lay and WISS-COLAY *Pre*formed.

THIS FREE BOOK SHOWS HOW TO MAKE WIRE ROPE LAST LONGER

"Know Your Ropes" contains 82 pages of suggestions on proper selection, application and usage of wire rope. This easy-to-read, profusely illustrated manual can save you money. For your free copy write Wire Rope Sales Office, Wickwire Spencer Steel, Palmer, Massachusetts.

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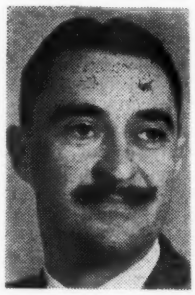
PACIFIC COAST:—The California Wire Cloth Corp., Oakland 6, Cal.

CF&I

Geo. E. Failing agent



John B. Weil

John B. Weil, Johannesburg, South Africa, is the new agent for the George E. Failing Supply Company in South Africa. Weil recently spent two weeks in the home plant of the Failing company in Enid, Oklahoma. The Failing company manufactures portable drilling and exploration equipment.

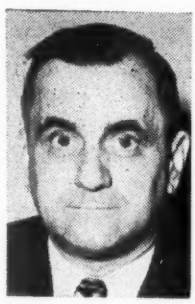
Made Fluor director

J. P. Wiseman

James P. Wiseman, general sales manager of The Fluor Corporation, Ltd., Los Angeles, California, has been appointed to the board of directors. The appointment was effective January 1. Wiseman, who has been with the company four years, was placed in charge of the sales division last September.

Acting field manager

Announcement of the appointment of Norris Green, of Birmingham, Alabama, as acting field manager of Thermoid Company's oil field products division has been made at the company's Trenton, New Jersey, headquarters by Jack Owen, vice president.



Norris Green

Named to replace Paul Kelting, who died in December, Green will have his headquarters at Thermoid's Houston office at 1121 Rothwell Street. Prior to this appointment he had been successful as district manager for Thermoid at Birmingham.

Organizations merge

Pacific Pipeline Construction Company and Engineers, Limited, have formed a partnership for conducting a general pipe-line construction business under the name Pacific Pipeline and Engineers, Limited. The new partnership brings together all the facilities of two leading pipe-line constructors in the West.

Pacific Pipeline Construction Company is well known among California oil and gas men for its part in constructing lines in all fields throughout the state. Engineers, Limited, constructed the Shell oil lines from Bakersfield to Martinez and have handled several major pipe-line projects in South America. They also constructed portions of the War Emergency "Big Inch" line and the Tennessee Gas and Transmission Company lines.

According to B. M. Laulhere, Jr., the management and policies of the new partnership will be the same as for Pacific Pipeline Construction Company. The merging of the two organizations will enable the company to expand its operations to serve the oil and gas industry to the fullest extent, it is stated.

Emsco promotes D. Duncan

H. H. Glen, president of the Emsco Derrick and Equipment Company, has recently announced the appointment of Dan Duncan to the position of executive engineer, in which capacity he will act as coordinator of the various engineering activities of the company.

Dan Duncan

A graduate from the University of California, Duncan first entered the oil business in 1921 as a roughneck for the Shell Oil Company in Ventura, where he was soon promoted to driller. His next five years were spent in Sumatra, Dutch East Indies, with an affiliate of the Shell Oil Company. Returning to the states, he successively worked as field engineer for the National Supply Company, Loffland Brothers, Inc., and the Emsco Derrick and Equipment Company, with whom he has been associated since 1939.

To new job

Knight C. Templeton, for many years connected with foreign sales of oil equipment, has joined the staff of Roland E. Smith, foreign sales representative with offices at 617 South Olive Street, Los Angeles, California. He will have his headquarters in Los Angeles but will make periodic trips to foreign fields, particularly in South America.

K. C. Templeton

Knight began his petroleum experience with the General Petroleum Corporation, serving in the production department from 1922 to 1926. He then went with the Elliott Petroleum Company and from there into the Elliott Core Drilling Company in 1929. His work with the latter company was in export sales until he transferred to Security Engineering Company in 1939. He has been with Security on foreign sales work ever since that time. During 1945 he was secretary-treasurer of the Los Angeles Basin Chapter of the American Petroleum Institute. Other activities include membership in the Los Angeles Chapter of Nomads.

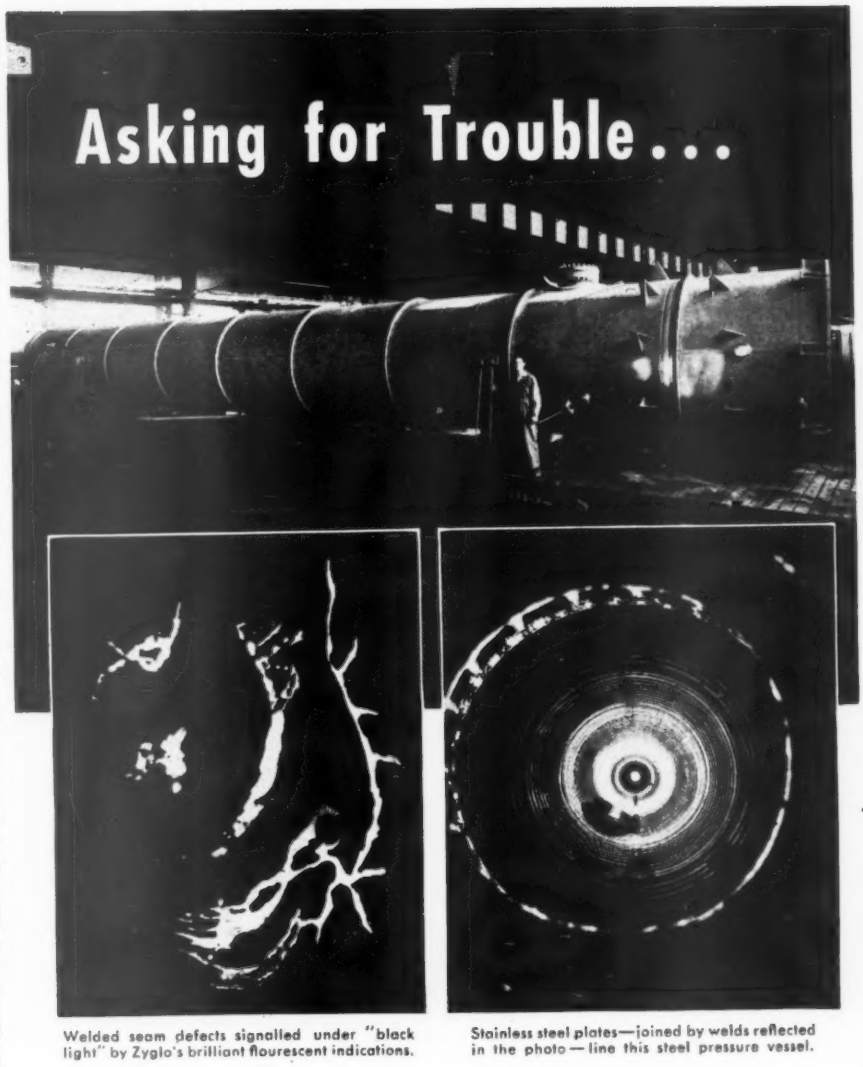
Supervisor of personnel

Appointment of Arthur G. Sanford as supervisor of personnel for the General Electric chemical department is announced by Dr. Zay Jeffries, General Electric vice president and general manager of the chemical department. Sanford has been personnel supervisor of the plastics divisions since 1937. His headquarters will be at department headquarters at Pittsfield, Massachusetts.

Closes Tulsa office

John L. Shaunty, Mid-Continent manager, of the Houston, Texas, Vapor Recovery Systems Company, is now in charge of all business in the Tulsa area since the closing of the Tulsa Vapor Recovery Systems Company office.

Communications should be addressed to: Vapor Recovery Systems Company, Texas M & M Building, Houston 2, Texas. The telephone is Fairfax 7909.



Welded seam defects signalled under "black light" by Zyglo's brilliant flouresent indications.

Stainless steel plates—joined by welds reflected in the photo—line this steel pressure vessel.

Forestalled by ZYGLO*

Corrosion, arch enemy of refiners, finds no entrance in welded pressure-vessel interiors inspected with Zyglo. Any surface flaws in the lining plates or welds . . . no matter how minute . . . stand out in warning brilliance.

Regular inspection of *all* refinery equipment with speedy, non-destructive Zyglo forestalls costly shut-downs and accidents. By clearly exposing fatigue cracks, weldment imperfections and other dangerous defects *before* failure, Zyglo provides economical endurance insurance.

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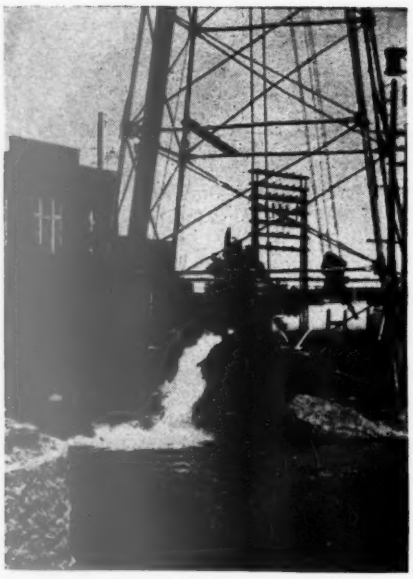


WATER
MEANS A LOT
TO CITIES LIKE SIOUX FALLS, S. D.

Sioux Falls, S. D., is a typical American City. Like many other smaller towns, it is growing into a much more important distribution and manufacturing point. Water for further growth was needed in large—but economical quantities. The choice was a Layne Well Water System that is now producing a million gallons daily.

Sioux Falls is not burdened by high operation cost, and furthermore there will be very little—or perhaps no repair expense for years to come.

Layne Well Water Systems, used and famous the world over, are engineered for heavier duty than ever called upon to perform. Such extra ruggedness and remarkably fine quality makes them an unmatched investment for any city or industry. These Well Water Systems are built in a wide range of capacities suitable for present needs and future growth. Space requirements are small and installations can be completed in a matter of weeks.

For further information, literature, etc., address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

HIGHEST EFFICIENCY

Layne Vertical Turbine pumps are available in sizes to produce from 40 to 16,000 gallons of water per minute. High efficiency saves hundreds of dollars on power cost per year.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Pacific, Inc., Seattle, Wash. ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada ★ Layne-Hispano Americana, S. A., Mexico, D. F.

LAYNE

WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

Make appointments

American Meter Company announces the appointment of Arthur F. Benson to the position of production manager of the company and its subsidiaries, effective January 1. Benson, who has been with American Meter Company since 1930, will also continue in his position as chief engineer, to which he was appointed January 1, 1943.

Simultaneously, the company has announced the appointment of William G. Hamilton, Jr., as sales manager of the company and its subsidiaries, also effective January 1. Hamilton joined American Meter Company December 1, 1927. He became assistant manager of the Philadelphia factory in June, 1941, and was placed in charge of war production during which time two "E" awards were won for the outstanding performance records of this plant. On September 27, 1945, he was appointed manager of the Philadelphia operations.

A. F. Benson

W. G. Hamilton, Jr.

Frank John promoted

K. W. Davis, president of the Mid-Continent Supply Company, with general offices at Fort Worth, Texas, recently announced the promotion of Frank John to the post of assistant to the president and director of purchases for this company.

Frank John

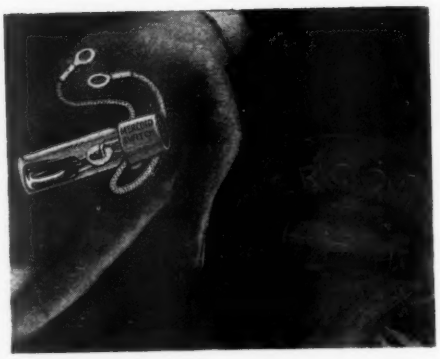
John has been associated with Mid-Continent Supply Company since 1931 when he was employed as store manager for the company at Kilgore, Texas. In 1933 he was transferred to Fort Worth as purchasing agent. In this new position, John will continue to direct purchases for the company with the new added responsibility of directing policies for its operation.

In new building

Seismic Engineering Company recently bought and moved into a new building and grounds at 6111 Maple Avenue, Dallas, Texas. Previously at 7000 Hines Boulevard, where a building was shared, Seismic Engineering Company required additional space for its present operations and future expansion.

Seismic Engineering Company, now operating 30 trucks throughout the country, including five complete seismograph crews, was formed in 1944 by C. G. McBurney, J. H. Pernell, and R. D. Arnett, all of whom were previously associated with National Geophysical Company. Explorations are currently being conducted over a three-state area.

The new plant is on a plot 100 ft wide by 650 ft deep and includes two buildings having a total area of over 3000 sq ft.



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Whatever your control requirements may be, it is conceded that the switch in a control warrants first consideration, due to its functional characteristics. All Mercoid Controls are equipped exclusively with hermetically sealed mercury switches of special design and selected materials.

Mercoid mercury switches are known the world over for their dependable service. They are not affected by dust, dirt or corrosion; nor are they subject to open arcing with its attendant consequences of pitting, sticking or oxidized contact surfaces, all of which, are likely to interfere with normal switch operation.

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MERCOID CONTROLS are available in a variety of types for sensitive control of Pressure, Temperature and Lever actuation.

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APPROVED CONTROLS

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Allen joins Thermoid

Appointment of T. E. "Ted" Allen to an important executive position with the Thermoid organization at its Trenton, New Jersey, headquarters has been announced by Fred E. Schluter, president of the company. Until recently executive vice president and general manager of the Brake Lining Manufacturers Association at New York, Allen resigned that position to accept the newly created post at Thermoid, made necessary by the company's substantial growth and the further expansion already in process to meet demands in new markets.

T. E. Allen

According to the announcement, Allen will serve as assistant to President Schluter on public and industry relations, and will assist the vice president of automotive sales and service. He will also supervise advertising policy and represent the company in industry association meetings.

New Ideco supply store

Opening of the new Ideco supply store at Hitschmann, Kansas, has been announced by C. A. McClelland of International Derrick and Equipment Company. Like other Ideco stores, this new store will also carry a complete line of oil-field equipment and supplies. Glenn Burris will manage the store and Charles E. Hamlin will act as sales representative. R. R. (Lefty) Matthews, district manager for Kansas, will supervise the activities from his headquarters at Great Bend.

On December 6, oil operators from the Hitschmann area attended a barbecue and officially inaugurated the new store into the supply business. More than 500 persons, representing about all the oil companies operating in Kansas, attended the opening ceremonies. Many old friendships were renewed during the day's activities.

Made purchasing agent

Harry E. Lorenz of Chicago has been appointed purchasing agent of Carnegie-Illinois Steel Corporation, it has been announced by R. L. Van Cleve, director of purchases of this United States Steel Corporation subsidiary. It was also announced that C. H. Baringer and F. G. Buchheit have been made assistant purchasing agents.

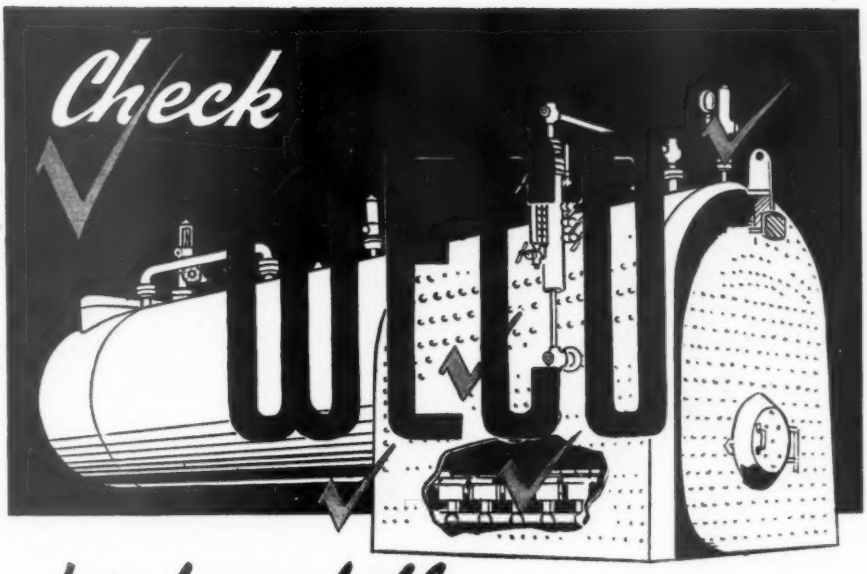
Joins Young Radiator

Young Radiator Company, Racine, Wisconsin, manufacturers of heat transfer products, has announced the addition of John P. Wahlen to its staff of sales engineers.

J. P. Wahlen

Wahlen was born in Urbana, Illinois, attended Lindblom High School in Chicago, and is a graduate of the University of Illinois, M. E., 1946. He served in the United States Army for 3½ years, a year and a half in the Coast Artillery, and two years in the Corps of Engineers on the Atom Bomb Project in New Mexico.

At Young Radiator Company, he is a sales engineer of the heating, cooling, and air conditioning division.



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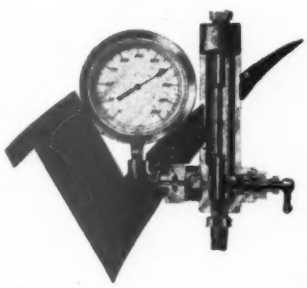
Boiler Equipment

ANCHOR LOW PRESSURE GAS BURNERS

More heat from less gas through advanced design . . . Air-Cooled heads . . . Longer life . . . Lower maintenance.



WECO STEAM GAUGE PROTECTORS

Built to comply with A.S.M.E. code . . . Prevent live steam from reaching gauge mechanism. Minimizes pulsation. Opening for Inspector's master gauge.

WECO FUSIBLE PLUGS

99 97/100 percent pure certified tin. Meets A.S.M.E. requirements. Give Maximum Efficiency.

OKADEE BLOW-OFF VALVE

Quick opening . . . self-closing for 450 lbs. SWP. Can be operated by remote control.

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WRITE FOR BULLETIN 104

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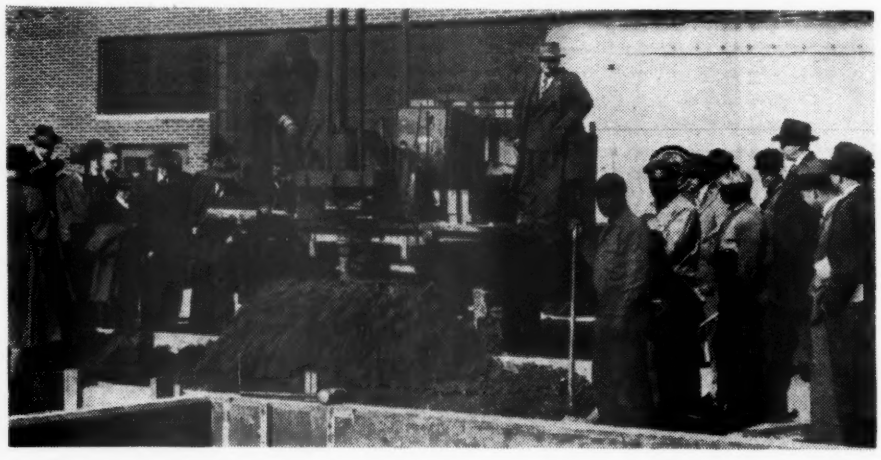
Buda earth drill on construction job

Drilling holes in the "modern fashion" might be the subject of a recent demonstration staged at the new Sinclair Refining Company research and development laboratory now under construction at 147th Street and the Illinois Central Railroad, Riverdale, on the south borders of Chicago. The occasion was the completion of the drilling of pier holes, using the Buda earth drill, on this important construction job being done by the Austin Company, contractors.

While officials of the Austin and Buda companies watched, the crew of the earth drillers demonstrated how it had completed the required 480 pier holes, each 42 in. in diameter ranging in depth from 11 to 13 ft, in 30 minutes or less each.

Top officials of the Austin Company at the demonstration included G. A. Bryant, president, Austin Company; J. K. Gannett, vice president and director of engineering and research; and M. W. Leek, district superintendent; and from the Buda Company: R. B. Fisher, vice president, and Lomar Kerlin, earth drill engineer.



Cummins promotions

Promotions of two officials of the Cummins Engine Company, Inc., Columbus, Indiana, have been announced by Hugh Th. Miller, chairman of the company's board of directors.

V. E. McMullen is now executive vice president of the company, and R. E. Huthsteiner vice president-general manager.

McMullen, who has been serving as vice president and general manager, joined the Cummins Engine Company, Inc., in 1935 as factory manager, after wide experience in the industrial field.

Prior to his promotion, Huthsteiner was vice president, assistant general manager, and controller. He joined the Cummins organization as sales manager in 1942.

The management of the Cummins Engine Company, Inc., simultaneously announced the appointments of Leonard W. Beck as general sales manager and Waldo M. Harrison as controller, both effective January 1.

Beck has been serving as acting general sales manager and manager of the company's central region. He now will relinquish the regional post. Harrison formerly held the position of assistant controller and materials manager.

Plane christened

At the Lockheed Air Terminal in Burbank, California, January 22, 1947, a colorful ceremony took place when Union Oil Company's new airplane, the "Asuncion," was christened by the lovely Mrs. Juan Pedretti, with Senora Maria Sanchez-Albarran adding further beauty and dignity to the occasion, as matron of honor. It was an interesting affair, engineered by A. C. Rubel, Union Oil Company vice president, who performed in his usual affable and capable manner as master of ceremonies, while Hubert Ferry did an elegant but unobtrusive job in the backfield.

The ship, a 12-passenger, twin-engined, Douglas C-47, goes to Paraguay to relieve the transportation worries of the field operators, and will no doubt be useful in many ways, in expediting developments, particularly in exploration work, and in the movement of personnel and supplies. It is being flown to its destination by Royce Stetson, Union Oil Company's chief pilot, with Chuck Brannon doing the honors as co-pilot, and Lew Williams officiating as mechanic. Upon arrival in Paraguay, Chuck Brannon will take over, and remain as pilot of the Asuncion.

The christening ceremony was attended by a number of Paraguayan dignitaries and Union Oil Company officials, and their friends, who later lunched together in the Sky Room, and then took a pleasure jaunt around the City in the sleek new ship. The sponsor, Mrs. Juan Pedretti, is the wife of Juan Pedretti, petroleum engineer and representative of the Paraguayan Government, here studying American methods of petroleum operation. The matron of honor, Senora Maria Sanchez-Albarran, is the wife of Senor Ramon Sanchez-Albarran, partner in the law firm of Barker and Albarran, Union Oil Company's legal advisers on Latin-American affairs.

Among other distinguished guests were Honorable Roberto J. Wilkinson, Paraguayan consul general, with Senora Wilkinson, and their charming daughters, Carmen and Margarita; Dr. Henry Alonzo dae-English, Paraguayan vice consul to Los Angeles, with Senora dae-English; Frederick Barker, senior member of the firm of Barker and Albarran, with Mrs. Barker; Reese Taylor, president Union Oil Company; Mrs. W. L. Stewart, Jr.; Mr. and Mrs. A. C. Rubel; Mr. and Mrs. A. C. Stewart; Mr. and Mrs. Ralph Marshall, Drilling and Exploration Company; Mr. and Mrs. H. W. Sanders; Henry Salvatori, president of Western Geophysical; Earl Herring, president Airmotive Corporation, and E. O. Locher of the same organization; Mr. and Mrs. Hubert Ferry; Mr. and Mrs. E. B. Noble; Mr. and Mrs. C. S. Perkins; Mr. and Mrs. Trees; Mr. and Mrs. Dick Gibson; S. H. Grinnell; and the wives of the three flyers—Mrs. Stetson; Mrs. Brannon, and Mrs. Williams.

Dr. Meinert promoted

To aid in the company's expanded research activities, Dr. Richard N. Meinert, for the last 10 years engaged in research work for Standard Oil Development Company at Bayway, New Jersey, has been named assistant chief research for The Carter Oil Company at its Tulsa laboratories.

Dr. R. N. Meinert

A native of Winona county, Minnesota, Dr. Meinert was graduated from high school at Lancaster, Pennsylvania, and did undergraduate work at Franklin and Marshall College, Lancaster, finishing there in 1927. In 1930, he received his Ph. D. degree in organic chemistry from Northwestern University, Evanston, Illinois.

He acepted a faculty assignment at Brown University, Providence, Rhode Island, that same year and remained there until 1936, when he went with the Esso organization at Bayway as research chemist.

H. F. Moses is vice president of Carter in charge of exploration and research and Dr. P. S. Williams is chief of research at the Carter laboratory.

Vincent service chief

W. L. "Billy" Vincent, former field service engineer for Magnet Cove Barium Corporation in Southwest Louisiana, has been promoted to the position of chief service engineer effective January 15.

In his new position, Vincent will have supervision over all Magcobar mud engineers and field service men. He will be stationed at the company's general sales offices in Houston, Texas.

John Hebert has been appointed to succeed Vincent in Louisiana and will make his headquarters in Lake Charles.

New G-E department

The General Electric Company has established an Affiliated Manufacturing Companies Department, and appointed Vice President L. R. Boulware as general manager, President Charles E. Wilson has announced. E. J. Harrington has been appointed manufacturing manager of the new department, and Roy W. Johnson marketing manager.

Boulware, who had been vice president on the president's staff, joined the General Electric Company following his wartime service with the War Production Board. Previously he had been vice president and general manager of the Celotex Corporation, Chicago.

Johnson was vice president in charge of sales for Telechron, Inc. During the war he was with the War Production Board, serving as director of the Facilities Bureau. Before the war he had marketing assignments with Schick, Inc., and General Electric.

Harrington has been on the staff of Boulware since October, 1945. During the war he was vice president of the Curtiss-Wright Corporation, and previously had been a manufacturing executive and industrial engineer and a general executive in the aircraft and automotive fields.

The manufacturing affiliates include Carboloy Company, Inc., General Electric X-Ray Corporation, Hotpoint, Inc., Locke Insulator Corporation, The Monowatt Electric Corporation, Telechron, Inc., and the Trumbull Electric Manufacturing Company.

Pumping Without Pampering

Huntington Beach, California, where this Case "DE" Oilfield Engine was photographed, is just like any oil area in one respect. The big thing is to keep oil coming up, keep manhours down. A big aid to both these aims is the ENDURANCE built into Case engines.

Their compact convenience shortens routine attendance. Quality construction in every part minimizes the risk of shutdown, reduces minor maintenance. Extra months of running before major overhaul holds performance high, holds overall costs low. Good governing and unfaltering power even at half-speed afford flexibility in rate of pumping.

Case Oilfield Engines are built in 28½, 42, and 61 H.P. sizes, and fitted for gas or liquid fuels. For full information call the distributor who maintains service in your area. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Machinery Company
1900 Linwood Blvd., Oklahoma City; Tulsa and Hobart, Oklahoma

Wm. K. Holt Machinery Company
San Antonio, Texas

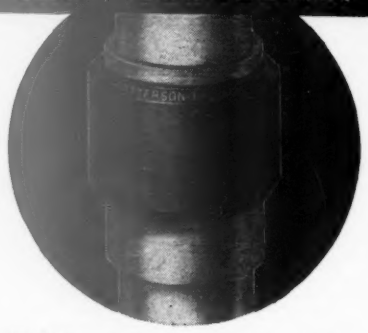
Southwest Equipment Company
Dallas and Kilgore, Texas

Goodman Bros., Inc.
Midland, Texas

OIL FIELD ENGINES

CASE

"Best Bet Yet"
SAVE YOUR TUBING!



Tubing collars worn by contact with casing steal the profit out of pumping. Patterson-Ballagh Plastic Tubing Protectors prevent both collar and casing wear. Oil-proof, wear-resistant, insulating. They are pressed onto the collar under pressure and will not come off. Made in all sizes. End your tubing troubles. CALL in your Patterson-Ballagh man.

Specify "Best Bet Yet"
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A DIVISION OF PATTERSON CORPORATION
PLASTIC
TUBING PROTECTORS

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6247 Navigation Blvd., HOUSTON 11
931 Russ Bldg., SAN FRANCISCO 4
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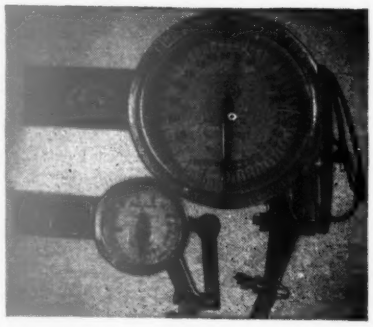
LINE SCALES



(Above) Super 500,000# capacity, 14" dial.
(Below) Packer Special, Capacity 40,000#, 6" dial. 18 other models for every drilling, well servicing, or work-over need.

20 MODELS to choose from

With a LINE SCALE you know the pull on the line, and the weight on the bit in pounds. Repeated tests prove the accuracy and dependability of LINE SCALE readings under all working conditions . . . even in areas of rapid temperature changes.

LINE SCALE CO., INC.
Box 4245 Oklahoma City Phone 6-765
Gulf Coast Representative: Hiram Wheeler
Box 8043, Houston 4, Texas—J2-1107

Sales conference

Announcement is made by the Peerless Pump Division of the Food Machinery Corporation of the completion of its first post-war general sales conference, recently held at the Los Angeles factory.

F. E. Fairman, Jr., vice president of the Food Machinery Corporation and general manager of the Peerless Pump Division, presided at the conference opening.

B. A. Tucker, division sales manager, conducted the week-long program, which, in addition to the discussion of Peerless' 1947 sales program, included a tour of the Peerless Los Angeles factory and foundry. Latest production and manufacturing methods were viewed and explained and observations were made of the new projects under way in the Peerless engineering department.

The following sales personnel were in attendance: E. W. Lundy, Los Angeles, Pacific District sales manager; E. W. Pierce, Canton, Ohio, Central District sales manager; W. E. Griffin, Dallas, Texas, Southwestern District sales manager; J. B. Madden, Atlanta, Georgia, Southeastern District sales manager; Ivor G. Morgan, Canton, Ohio, small products sectional sales manager; E. E. Bauer, Quincy, Illinois, central sectional sales manager; L. H. Stermer, Los Angeles divisional manager of manufacturing; Don Rankin, Los Angeles, divisional chief engineer; E. H. Hansen, Fresno, California, district manager; H. L. Drew, Phoenix, Arizona, branch manager; V. L. Ray, Los Angeles, auditor; J. C. Bonsall, Los Angeles, export manager; W. H. Day, Los Angeles, assistant to division manager; J. B. Downey, Los Angeles, publicity; H. S. Kern, Los Angeles, sales assistant, and R. C. Engemoen, Los Angeles, sales assistant. W. E. Vaughan, Philadelphia, Pennsylvania, Atlantic District sales manager was unable to attend the conference.

Midweek activities consisted of complete sales conferences and discussions, including plans for additional complete service to distributors and customers.

Change in firm name

Effective January 1, the name of Bechtel Brothers McCone Company, engineering and construction organization, was changed to Bechtel Corporation. At the same time, three subsidiaries became respectively Bechtel International Corporation, Compania Bechtel, S. A., and International Bechtel, Inc.

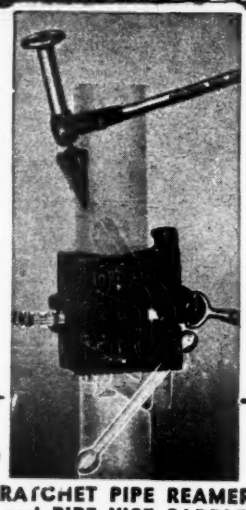
The change was made, it was announced, in the interest of simplification and convenience. The organization's policies and the scope of its services as engineers and constructors engaged on governmental and privately owned projects of a varied nature throughout the world, will remain as in the past.

Principal officers are S. D. Bechtel, president; W. E. Waste, Van W. Rosendahl, J. Perry Yates, V. G. Hindmarsh, Jerome K. Doolan, and C. Stribling Snodgrass, vice presidents. Executives and key personnel have been closely associated for many years in the extensive activities of the Bechtel interests. Headquarters and major engineering offices are in San Francisco. An engineering staff is also maintained in Los Angeles, and elsewhere on the basis of projects under construction.

Advertising counsel

American Meter Company, New York, manufacturers of devices for the measurement and control of gases and liquids, has appointed Hixson-O'Donnell Advertising, Inc., as its advertising counsel.

Look for the Arm-and-Hammer
ARMSTRONG BROS.



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Use an ARMSTRONG BROS. Ratchet Pipe Reamer to assure full capacity, trouble-free pipe work. Its spiral fluted reamer quickly eliminates all inside burrs for it is milled, ground and hardened. Its drop-forged reversible ratchet operates in the closest quarters—only 12½-degree handle swing required. Will give lifetime service.
The ARMSTRONG BROS. Pipe Vise Saddle brings the vise to the point of work. Attaches instantly to any pillar or post and provides a secure base (and pipe or conduit bender) for either hinged, chain or open side pipe vises

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Write for Bulletin No. 102 which shows why and how

BLACKMER PUMPS
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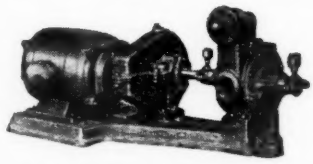


Gathering Pumps • Refinery Pumps
Bulk Station and Truck Pumps
Hand Pumps • Suction Line Strainers
Capacities to 750 GPM—Pressures to 300 psi

BLACKMER PUMP COMPANY
1980 Century Avenue Grand Rapids 9, Mich.

SERVING THE PETROLEUM INDUSTRY FOR 40 YEARS

Brown promotions

Henry M. Schmitt has been named chemical industry manager of the Brown Instrument Company, Philadelphia. O. B. Pyle has been made industrial manager of the Philadelphia branch and A. W. Roat is now industrial manager of the St. Louis branch of the industrial division of Minneapolis-Honeywell Regulator Company.

The sales executive staff changes were made known by W. H. Steinkamp, field sales manager for Brown. At the same time Steinkamp announced that I. K. Farley has been placed in charge of the major petroleum accounts in the Philadelphia area and Harry D. Ruch will also work out of the industrial sales division at Philadelphia.

Schmitt has been with the Brown company for the last 22 years. His successor, Pyle, has been with Brown for 18 years and is the holder of high sales records.

Roat succeeds to the position held in the recent past by V. H. Hiermeier who has been transferred to the Honeywell international division. He will probably be assigned to a foreign post. Roat has been with the company nine years during which time he has served in Pittsburgh, Cleveland, and Philadelphia.

"Oilwell" appointments

Appointment of H. P. Fogle as assistant manager of the Gulf Coast division of Oil Well Supply Company, a subsidiary of U. S. Steel Corporation, was announced by Paul H. Shepherd, division manager. The company's Gulf Coast division headquarters are in Houston, Texas.

Shepherd also announced the appointment of T. C. Tweedie as head of the subsurface department of the division.

After joining "Oilwell" in 1935, Fogle served in Shreveport, Louisiana, and Pettus, Corpus Christi, and San Antonio, Texas, before going to Houston in 1944 as a division sales representative. He became division manager of tubular sales in 1946.

Tweedie, a native of Scotland, joined the company in 1946 as an engineer in the subsurface department of the Gulf Coast division.

National headquarters of Oil Well Supply Company are in Dallas, Texas.

Oil Base appointments

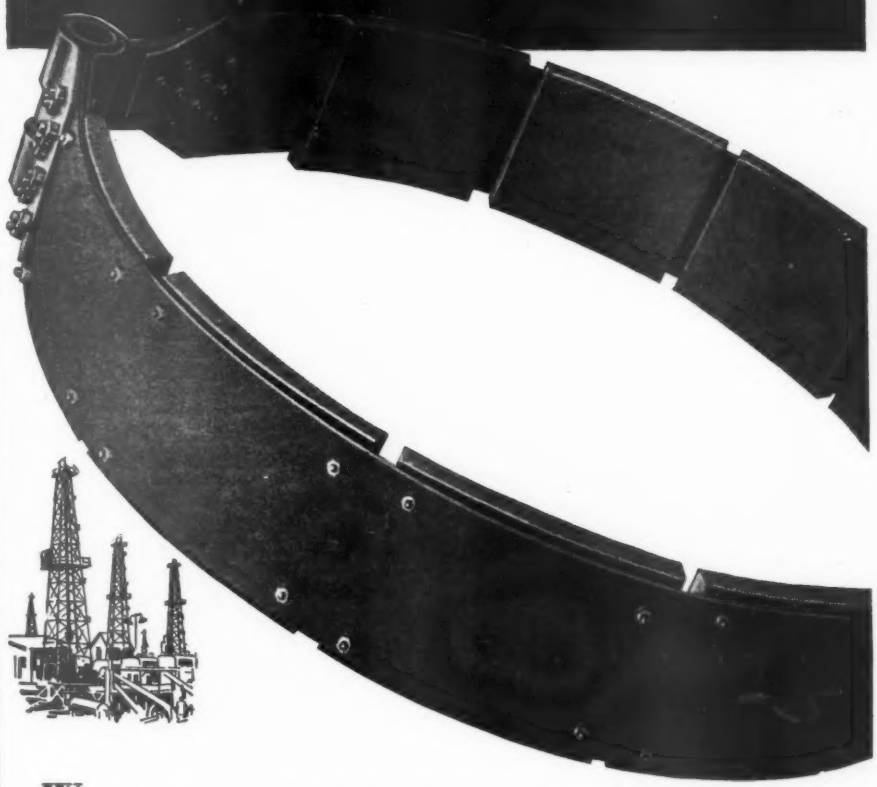
Oil Base, Inc., Los Angeles, manufacturers of Black Magic oil base drilling muds, announces the recent appointment to its sales staff of Arthur K. Brown who has been assigned the Rocky Mountain area with headquarters in Vernal, Utah. Brown was formerly with Shell Oil Company, U. S. Bureau of Mines, and Baroid Sales Company. He is a graduate of Texas A. and M. and well acquainted with all phases of oil-producing operations throughout the country.

Ralph Ruse has been transferred from the Rocky Mountain area and placed in charge of the West Texas area with headquarters at Odessa, Texas. Ruse has been with Oil Base, Inc., since the company's origin. He was formerly with Baroid Sales and has served with the University of Texas' staff conducting a field school on mud control in the Rocky Mountain areas.

Schultz to export

The transfer of T. N. Schultz, former sales engineer for the Tulsa division of the Mid-Continent Supply Company, to the company's New York officie to devote all his time to the rapidly expanding export business, was announced by K. W. Davis, president, at the company's recent sales meeting.

Thermoid woven brake lining for all standard Drawworks



When it's time to reline the bands of your drawworks, use Thermoid's "built for the job" woven brake blocks or roll lot lining. Built with a thorough understanding of the heat factor need in this service, Thermoid TX or TXE will provide a longer work period between relinings, and will "feed-off" correctly, right down to the bolts!

It's a woven material, containing a balanced ratio of asbestos and other raw materials. The asbestos is woven to proper thickness in a single layer. The treatment by special processes is forced into the entire thickness of the lining and ground to correct radius.

IT'S "BUILT FOR THE JOB" ALL RIGHT! More than 300 types of drawworks, the product of 32 manufacturers are listed in our Bulletin 3001, and the brake specifications of each is given together with list prices. Ask for Bulletin 3001—Oil Field Brake Lining.

ROTARY BRAKE BLOCKS • WOVEN OIL FIELD BRAKE LININGS • ROTARY HOSE SLUSH PUMP HOSE • FLEXIBLE DISCHARGE UNIT HOSE • HOSE OF ALL TYPES • V-BELTS AND DRIVES • OIL COUNTRY BELTING • STUFFING BOX RINGS • "NO WIP" LINE SAVERS • WIRE LINE TURN BACKS • PIN TYPE PIPE PROTECTORS • MOLDED PRODUCTS

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Hotel Texas ..... Fort Worth
Hotel Buccaneer ..... Galveston
Hotel Galvez ..... Galveston
Hotel Jean Lafitte .. Galveston
Coronado Courts ... Galveston
Jack Tar Court Hotel Galveston
Miramar Court ..... Galveston
Hotel Cavalier ..... Galveston
Hotel Plaza ..... Laredo
Hotel Lubbock ..... Lubbock
Hotel Falls ..... Marlin
Hotel Cactus ..... San Angelo
Hotel Menger .... San Antonio
Angeles Courts ... San Antonio
VIRGINIA
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Executive Offices
Galveston
Texas

CBS announcer Bill Downs, left, plays the role of "Mr. Average Citizen" as he questions D. I. Johnston, center, and Gwynne Raymond, right, about that March 15 boogie, income tax.

BS&B becomes "Crossroads—U.S.A."

Black, Sivalls and Bryson's manufacturing plant at Oklahoma City became a Columbia Broadcasting System studio Saturday, January 18, when BS&B's chief engineer, Gwynne Raymond, and D. I. Johnston, Oklahoma Associated Industries counsel, were featured in a discussion of income taxes on the program "Crossroads—U.S.A."

CBS announcer Bill Downs, eyewitness reporter of the Bikini Atoll atom bomb tests, interjected questions to bring out the points Raymond and Johnston were stressing. Both men, speaking from the viewpoint of industry generally, favored NAM's program for a 20 per cent reduction in personal income taxes to apply to 1947 incomes.

"I don't see why this can't be done," Raymond said. "I've dug up some government figures that will give you some idea of what is going on. Taxes are taking almost one-third of the national income." He continued, "Corporation taxes, for example, amount to about seven times what they did before the war. And as for individual income taxes, listen to this. The government is getting 14 times as much return from personal income taxation as it did in 1939."

Raymond further pointed out that President Truman's present budget calls for eight billion dollars in direct taxes on corporations—six and one-half time the amount collected from corporations in either 1939 or 1940.

Both Johnston and Raymond agreed that tax reduction might well act to bring about greater federal returns than ever by stimulating business development and activity without fear of punitive taxes.

To Bureau staff

Dr. Homer D. Holler, noted chemist and one of the leading authorities in the field of underground corrosion, has been appointed to the staff of the National Bureau of Standards, according to an announcement by Dr. E. U. Condon, director of the bureau. Dr. Holler, who has directed pioneering studies in electrochemical and corrosion work in two former tours of duty at the Bureau, will work with Dr. I. A. Denison of the Underground Corrosion Section. He joins the bureau's staff from the Westinghouse Electric Corporation where he has been responsible for corrosion investigation and control since 1929.

Dr. H. D. Holler

To new job

Myrl Fitzgerald, who has been employed by the George E. Failing Supply Company of Enid, Oklahoma, as a field man since his return from service in the European Theater with the Army Air Forces, has resigned to take a new job with the Arctic Contracting Company in Alaska.

Fitzgerald's new assignment will be as a core driller on a Failing Model 314-C working in the Navy's Petroleum Reserves near Point Barrow, Alaska.

Previous to the war Fitzgerald worked as a core driller in the Gulf Coast states of Texas and Louisiana.

Lawton Johnson promoted

G. Lawton Johnson has been appointed assistant general manager of sales of National Tube Company, it is announced by H. J. Wallace, general manager of sales of this U. S. Steel subsidiary.

Johnson will handle the sale of products manufactured at Christy Park Works, McKeesport, Pennsylvania, and some of the company's other fabricated products.

Native of Lawton, Michigan, he formerly was sales engineer for the Midwest Pipe and Supply Company and later was manager of eastern sales for the Graver Tank and Manufacturing Company, both in New York.

National Tube Company's Southwest division offices, supervising operations in six states, are located in Dallas.

Exclusive distributor

The appointment of Chiksan Company, Brea, California, as exclusive distributors of the Okadee gasoline loading rack valve has been announced by Lee J. Laird, vice president and sales manager of Chiksan Company.

In addition to covering the domestic market through Chiksan Company, Laird states that foreign sales will be handled exclusively by Chiksan Export Company, which also represents Chiksan Well Equipment Manufacturing Corporation, and the complete line of Okadee valves for export.

The combination of Chiksan ball-bearing swivel joints, "Weco" unions, and Okadee valves makes possible a complete service for all types of loading and unloading lines of uniformly high quality and dependability, Chiksan officials point out.

Menden to Young Radiator

Young Radiator Company, Racine, Wisconsin, has announced the addition of P. J. Menden to its heating, cooling, and air conditioning division. For several years Menden was associated with different heating and ventilating contractors in the Racine-Milwaukee area. He was later employed as a sales engineer by the W. H. Gilcher Company in Fairbanks, Alaska, manufacturer's representative. Returning from Alaska in December, 1941, he took part in the supervision of the installation of several processing plants for Mid-west manufacturers as well as maintaining a consulting service for architects and heating and ventilating contractors in southern Wisconsin.

P. J. Menden

At Young Radiator Company, Menden will assist in the development and improvement of heating, cooling, and air conditioning products, as well as application engineering for the heating, cooling, and air conditioning division.

Price policy adopted

In an attempt to stabilize prices in the oil industry field, the Lufkin Foundry and Machine Company, Lufkin, Texas, established a firm price policy January 27, by slicing off the conventional stipulation "Price in effect at time of delivery."

W. W. Trout, vice president and general manager, stated "We believe Lufkin has been a definite factor in holding down the price of pumping units to a reasonable level, and it will be our policy to continue to do so as best we can."

Commenting on the stand that the company is taking relative to the discarding of the customary reservations on listed prices, Trout said, "Effective January 27, this clause (price in effect at time of delivery) will be left off all our quotations. We realize there is considerable hazard in taking this step, particularly at time when we have an extremely large backlog of orders.

"We are writing all of our material suppliers, advising them of our action and requesting that they do the same for us. Concerted effort will stop inflation."

Organization changes

Organization changes in the General Electric chemical department establishing the plastics division and the compound division in place of the former plastics divisions are announced by Dr. Zay Jeffries, vice president and general manager of the department. Simultaneously, Dr. Jeffries announced the appointments of George P. Lehmann as manager of the plastics division and John L. McMurphy as manager of the compound division. Both men will make their headquarters in Pittsfield.

C.N.G.A. fall meeting

Friday, October 10, was set as the date of the California Natural Gasoline Association's 1947 Fall Meeting by the association's executive committee at its January meeting. The annual fall meetings serve as forums at which speakers of national prominence discuss the technical problems of the industry. As in past years, a dinner and show will follow the daytime technical sessions. The meeting will be held at the Ambassador Hotel in Los Angeles.

THE SYMBOL OF PACKING SATISFACTION

Throughout American industry the name France, stands for metallic packing of the highest excellence. To men whose responsibility it is to see that engines, pumps and compressors continue to give unfailing performance, this name is the symbol of packing satisfaction.

France packing embodies design, which is the outgrowth of specialized engineering effort and long experience. Thousands of installations, over a period of fifty years, attest to a matchless record of performance, durability and decreased operating costs.

There is a France packing for every industrial requirement for steam, air and gas units, including ammonia and CO_2.

Write for Our Latest Bulletin, "Industrial Packing".

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PIPE THREADS
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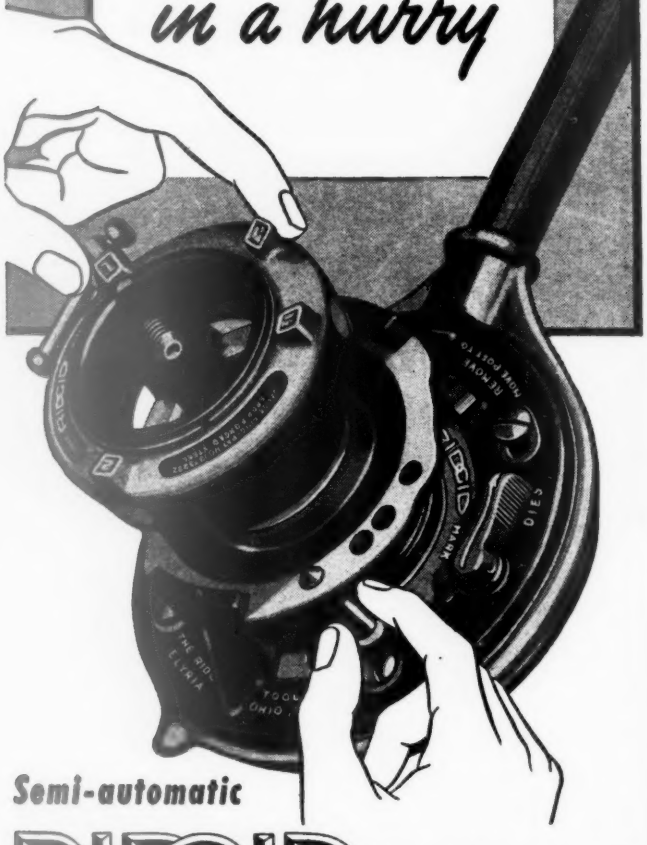

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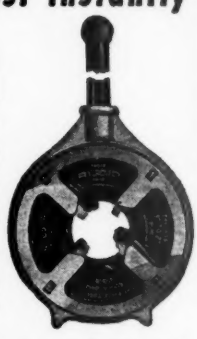

It stands up handily on the floor.

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WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO

Rockwell Manufacturing appointments

Three appointments to the executive staff of the Rockwell Manufacturing Company, Pittsburgh, Pennsylvania, have been announced by W. F. Rockwell, Jr., vice president and general manager.

C. A. Wiken, for the last eight years chief engineer of the Delta Manufacturing Division in Milwaukee, has been promoted to the position of vice president in charge of engineering for the Rockwell Manufacturing Company. He will coordinate the engineering activities of the various divisions and subsidiaries, supervise the standardization of engineering procedures and materials, and adminster company-wide policies relating to engineering.

J. E. Ashman has been named controller of the Rockwell Manufacturing Company. He comes to the Rockwell organization after four years with United States Steel as director of procedure for Carnegie-Illinois Steel Corporation, 13 years as national enterprises representative for the Burroughs Adding Machine Company, and a further background of corporate financial, sales, and management consulting experience.

A. E. McIntyre, who for the last several years has been manager of the Nordstrom Valve Division plant in Oakland, California, has been transferred to Pittsburgh as general manager of the company's Pittsburgh Equitable Meter Division. McIntyre came to the Nordstrom Valve Division after 17 years with the Caterpillar Tractor Company plant near Oakland, where he was factory manager. He will continue to serve as manager of the Nordstrom Valve Division.

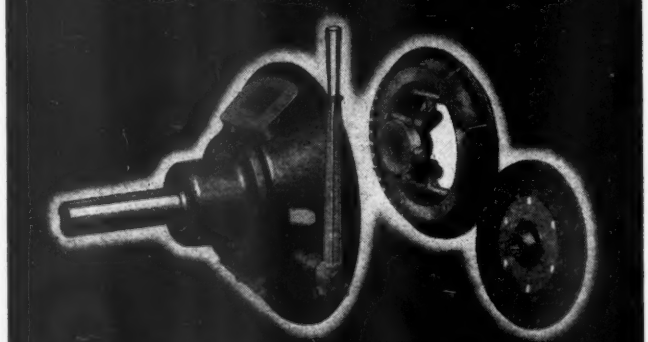
All three men will make their headquarters at the company's general offices in Pittsburgh.

C. A. Wiken

J. E. Ashman

A. E. McIntyre

ROCKFORD



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SELF CONTAINED UNIT
WIDE RANGE OF SIZES
CONSERVATIVE RATING
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S.A.E. DIMENSIONS

*ROCKFORD POWER TAKE-OFFS are available in eleven standard sizes, ranging from 160 foot pounds to 2000 foot pounds torque. Clutch sizes range from 6 to 20 inches. Either over-center or spring loaded clutches are optional and are interchangeable.

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Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

BW

ROCKFORD CLUTCH DIVISION BORG-WARNER

1303 Eighteenth Avenue, Rockford, Illinois, U.S.A.

Gate valve exhibited

"The inside story" of OIC steel gate valves was told in an unusual manner by The Ohio Injector Company, Wadsworth, Ohio, at the recent New York Power Show when that company exhibited a huge plastic valve, only one of its kind in existence. An ingenious arrangement constantly kept the "gate" opening and closing so that spectators could view its mechanism in operation. In the photo M. W. Pauly, left, OIC New York manager, and W. C. Davis, the company's sales promotion manager, are comparing a smaller OIC valve with the large plastic model.

Heads Maloney-Crawford Tank

Announcement of the election of S. P. Wallace as president and treasurer of the Maloney-Crawford Tank and Manufacturing Company, has been made following a recent meeting of the firm's board of directors.

The board of directors consists of O. W. Maloney, vice president, J. C. Highfill, vice president, Lawrence E. Davis, Joseph M. Handlan, and Wallace.

S. P. Wallace

Davis and Handlan, both residents of Parkersburg, West Virginia, were elected members of the board in December.

Davis is connected with the Crawford estates. Handlan is a son of the late Harold D. Crawford, former president of Maloney-Crawford.

Wallace, former Parkersburg Rig and Reel executive, has been vice president and sales manager of Maloney-Crawford for the past year.

Having doubled its plant facilities during the war period, increased manufacturing facilities are now available for the firm's bolted and welded steel tanks, high and low pressure oil and gas separators, and heat treating units. Wallace reports that Maloney-Crawford anticipates a big year during 1947 with the firm having the largest sales and service force in its history.

Booklet on engineering committees

Organization and functioning of oil-field engineering committees is the subject of a booklet just released by the Interstate Oil Compact Commission.

The publication contains report of a subcommittee of the commission's legal committee, appointed to study the subject of oil-field engineering committees and draft provisions suitable for use in their organization.

Included also are organization agreements of 11 engineering committees, as follows: Yates, Conroe, East Texas, Goldsmith, North Basin, Carthage, LaGloria, Seeligson, Lea County, West Edmond, and Mississippi.

The pamphlet is being distributed from the Commission's headquarters office, Box 3185, Oklahoma City, Oklahoma.

● Now you can ream pipe or conduit easily and quickly without risk of thinning, flaring or splitting it. Extra long taper of this RIDGID Reamer whisks burr out safely in a few feather-light ratcheted strokes. Comes complete with ratchet handle. Save effort (and pipe) — buy it at your Supply House.

Reamer unit fits RIDGID No. 00R Ratchet Threader Handle, also.

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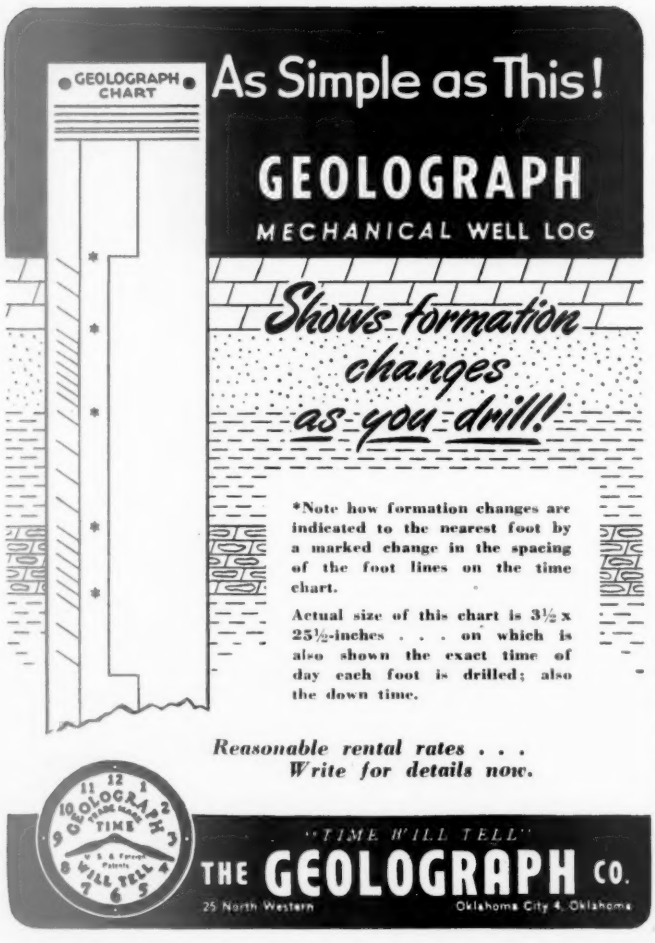
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As Simple as This!
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MECHANICAL WELL LOG
Shows formation changes as you drill!
*Note how formation changes are indicated to the nearest foot by a marked change in the spacing of the foot lines on the time chart.
Actual size of this chart is 3½ x 25½-inches . . . on which is also shown the exact time of day each foot is drilled; also the down time.
Reasonable rental rates . . . Write for details now.
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Varied experience in the design and production of Pumps of all types for Oil Field Service, McGOWAN Pumps will give you the ultimate in efficient service. Our engineering department is available for information on installations and requirements.
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Steel demand to exceed supply

Even though the steel industry reaches and maintains capacity production during 1947, the supply of pipe and tubular goods for the oil industry will fall short of the expanding demand, according to a recent prediction by John E. Goble, president of the National Tube Company, a subsidiary of the United States Steel Corporation.

Tubular goods for 28,000 wells may be available during this year, but the steel industry is faced not only with an increasing demand for steel for construction and expansion in other customer industries but also with a need for steel to construct new steel making facilities.

Barring strikes or other difficulties, the supply of pipe should increase after March, 1948, when National Tube hopes to complete its new 15,000-ton per month seamless pipe mill at Lorain, Ohio. Another mill of the same type and capacity will be completed sometime later at Gary, Indiana. These mills will manufacture 4-in. to 2-in. sizes of seamless pipe.

The steel industry as a whole supplied the oil industry with about 4.8 million tons of tubular goods during 1946, or about 20 per cent more than the average amount supplied during the four prewar years, according to William F. McConnor, vice president of National Tube, who accompanied Goble on his recent trip to a Southwest sales force meeting at Dallas.

John E. Goble, left, president National Tube Company, and W. F. McConnor, vice president.

New officers Houston Nomads

Officers of the Houston Chapter of Nomads to serve during the year 1947 were installed recently at a dinner dance given at the Rice Hotel. Nearly 500 Nomads and their guests attended the affair. During the evening the retiring president, Charles W. Thornhill, was presented with a gift in silver as a token of appreciation for his work during the past year. The officers, shown in the picture, are, left to right: Seated: Charles E. Richards, Gray Tool Company, president; Geo. E. Tyson, J & L Supply Company, vice president; C. L. Clausel, A-1 Bit and Tool Company, secretary-treasurer; H. J. Wood, Lebanon Steel Foundry, assistant secretary-treasurer; Jack Barnes, Trinity Portland Cement Company, sergeant-at-arms. Standing: Edwin Ross, Baash-Ross Tool Company, deputy sergeant-at-arms; Floyd L. Senter, National Tank Company, regent; Charles W. Thornhill, Thornhill-Craver Company, past president and regent; Harry E. Estes, Reed Roller Bit Company, executive secretary.

• **Drilling and Production Practice, 1945.** *Published by the American Petroleum Institute, 50 West 50th Street, New York 20. Pages, 212.*

Papers on drilling and production practice selected for the annual issue from those prepared and released for publication, or prepared and presented at national or district meetings of the Division of Production during 1945.

These papers are grouped in three sections covering production practice, materials, and miscellaneous. In addition, the volume contains a bibliography of all papers presented at the Pacific Coast district meeting in 1945.

The book preserves these selected papers in a more convenient form and in more permanent binding, than has been possible with the yearly paper-covered bulletins of annual meetings.

• **Twentieth Century Petroleum Statistics, 1946,** *by DeGolyer and MacNaughton, Dallas, Texas. Pages, 60. Price, $7.50.*

Compiled in this handbook are many and varied tables from original sources. The tables cover crude production and proved reserves of countries and states; percentage of refinery yields of asphalt, coke, and the production at the refineries; average life of wells; demand for crude oil, and numerous tables concerning crude oil itself. The daily average of crude stocks, consumption, imports, exports, production and runs to stills is tallied. Drilling, dry holes, discoveries, gas oil and fuel, lubricants, motor fuel, oil wells, pipe lines, wax and wholesale price, etc., are covered.

The booklet is the outcome of the Navy's wartime need for economic studies on various aspects of the petroleum industry. It should prove a ready reference to members and students of the petroleum industry.

Service managers and salesmen meet

Service managers and salesmen of the Cummins Sales and Service, Inc., of Fort Worth, held a one-day conference at the Blackstone Hotel January 26. The meeting was presided over by John E. Everroad, general manager. It is planned to extend complete Cummins Diesel service and export facilities more extensively in 1947.

Bob Eiche heads Los Angeles Nomads

Los Angeles Nomads have the following 1947 officers, who were duly installed at the Inaugural Ball at the Biltmore Hotel, on Saturday, February 15: President, R. J. Eiche; vice president, Fred Ripley, Jr.; secretary, Byron Landis; treasurer, Waldo Moore; sergeant-at-arms, Lee Laird; assistant secretary, J. Engstrand; assistant treasurer, B. Reinhold; deputy sergeant-at-arms, Earl Boggess; regents, Ted Sutter and Bill Bettis.

The nominating committee consisted of Elmer Decker, R. J. Eiche, Jack Ballagh, Jim Robinson, Earl Daniels, Wallace Sawdon, W. F. Bettis, chairman, Dan Duncan, Henry Pullman, E. B. Fowks, and Billy McGraw.

1947 officers Los Angeles Nomads. Top row, left to right: J. Engstrand, Byron Landis, R. J. Eiche, Fred Ripley, Jr., Waldo Moore, B. Reinhold. Bottom row, left to right: Ted Sutter, Lee Laird, Earl Boggess, Bill Bettis.

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